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SCIENCE
PHILOSOPHY AND
CULTURE

Multi-disciplinary Explorations

PART ONE

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SCIENCE PHILOSOPHY AND CULTURE

Multi-disciplinary Explorations

PART ONE

EDITED BY

D. P. Chattopadhyaya

Ravinder Kumar

PROJECT OF HISTORY OF
INDIAN SCIENCE, PHILOSOPHY AND CULTURE
in association with
INDIAN COUNCIL OF
PHILOSOPHICAL RESEARCH

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TO THE MEMORY OF
THE PIONEERS OF HISTORY OF SCIENCE AND
CULTURE IN INDIA

P.C. Ray • B.N. Seal

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S.N. Sen • Debiprasad Chattopadhyaya

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Preface

This volume, *Science, Philosophy and Culture: Multi-Disciplinary Explorations* (Part One), is being published by the Project of History of Indian Science Philosophy and Culture (PHISPC). To start with, such expression as 'Indian Science', 'Science in India', 'Indian Philosophy', 'Philosophy in India', 'Culture', 'Civilization' and the nature of their conceptual linkages are likely to raise question and confusion. It is well recognized that developed natural sciences of today are not ordinarily identified by their geography or land of origin. They are claimed to be objective, if not universal, despite the difference of their interpretations. But in the context of history, especially ancient and medieval, one feels that expressions like 'Greek Geometry', 'Chinese Astronomy', 'Arabic Alchemy', and 'Indian Medical System' are quite admissible and free from ambiguity. While the name of the Project remains what it is, PHISPC, attempt has been made to give a clear title to the volume.

As the Project is multi-disciplinary and very comprehensive in scope its Advisory Committee members thought that, before we bring out the main ten volumes, each consisting of two or more parts, it would be advisable to start our publication programme with unpriced Occasional Papers for free distribution, followed up by priced Monographs of varying length, and one or two Conceptual or Overview Volumes. The intention is to indicate the progress and continuity of the Project, and to present a fair idea of the works being done by the Editorial Fellows and their collaborators contributing to different volumes under preparation. Till date, twenty-four Occasional Papers and four Monographs have been published. Most of the materials

presented in this volume are new and have not been published before either under the auspices of PHISPC or elsewhere. The part two of this volume and three more monographs, one on Historiography of Civilization, another on Medical History and the third on History of Art are scheduled to be brought out early next year. Beside, parts of three main volumes, I, III and IV are likely to be brought out by 1996.

This Project is fully funded by the Government of India. Formally launched by the Indian Council of Philosophical Research (ICPR) in 1990, it has received the support from the Department of Science and Technology (DST), the University Grants Commission (UGC), the University of Delhi, the Ministry of Human Resource Development, Department of Education, Government of Rajasthan, and the Planning Commission. To all the concerned decision-makers we remain very grateful.

It is with a deep sense of loss that we remember the passing away of our very dear two editorial colleagues, Debiprasad Chattopadhyaya Sr. and S.N. Sen and G. Ram Reddy, the former Chairman of the UGC and of the Indian Council of Social Science Research (ICSSR). The grace and commitment which marked their cooperation with the Project are unforgettable.

The various suggestions and critical comments received from the academically distinguished members of the Advisory Committee have been an invaluable input for the qualitative improvement of the Project.

Our deepest debt is to our Editorial Fellows and the scholars who are working for a cause, viz., critical and constructive discovery of the past of India both for the present and the future, for ourselves and others.

D. P. CHATTOPADHYAYA

RAVINDER KUMAR

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Introduction

When several volumes of the Project of History of Indian Science, Philosophy and Culture (PHISPC) are under preparation, many of us actively associated with this venture felt that it would be a good idea to bring out a book which will give an outline of what the Project is about. It may not be always easy for a reader to grasp unaided the basic points of a comprehensive interdisciplinary Project like ours. Still more difficult may prove to identify the focus.

On political history of India numerous books are coming out in steady flow. Instructively, these books are written from different perspectives, not infrequently shifting emphasis from dynastic rule to attending techno-economic conditions. Publications on social history are also encouraging in number and quality. A good number of books on philosophy is addressed, for understandable reasons, to different historical schools, periods and authors, and not situated explicitly in their social context. Some of these works are textual and some interpretative.

For various reasons and unreasons the composite discipline of history and philosophy of science in India is still in its infancy. And publications in this area are relatively few. However, of late, some encouraging moves are afoot. The situation obtained in the field of technology is rather paradoxical. Interest in and need of technology are spreading fast but studies in its historical and theoretical aspects are very few. The academic and research authorities, IITs and CSIR in particular, are expected to take more initiative in the matter.

The story of culture, from a different point of view, also appears somewhat paradoxical. Culture is so pervasive in its nature and scope that everyone of us is familiar with one or the other facet of it. But rare are the

persons who take the trouble of spelling out clearly what culture is. While the cultural objects are easily identifiable, culture as a concept is hard to define. The difficulties of one's understanding get doubly compounded when one is called upon to conceive of an inter-disciplinary history of science, technology, philosophy and culture. What are the basic constituents of this type of Project? Where lies its focus?

Merely by enumerating the names of the disciplines covered by the Project, it is difficult to get a clear picture. Science is not a single discipline. To the layman, for example, physics, chemistry, mathematics are all scientific disciplines. There are various other branches of science—chemistry, biology, geology and so on. But, as we know, due to increasing specialization, each one of these sciences has various areas within itself. Even the number of the specialized disciplines is proliferating fast. To draw an exhaustive or even comprehensive catalogue of different sciences is sure to prove unrewarding for our purpose.

A somewhat similar situation we come across in the area of culture. In a non-trivial sense all ideas and things due to humans are cultural. Whatever is not natural is said to be cultural. But reflection makes it plain that the border line between the natural and the cultural, thanks to the growth of knowledge and technology, keeps on changing all the time. Theoretical investigation and technological innovation change not only the frontiers of different sciences but also the line of demarcation between nature and culture.

Sophisticated psychological techniques are being put to use through mass media and otherwise to influence people's disposition, citizens' orientation, and consumers' choice. From techniques to technology is not a long hop. History of technology brings out the point clearly. Theory or philosophy of technology convincingly shows us that visible technology has its invisible effects on such diverse 'things' as theories and minds.

Culture has been conceived under many heads, material and spiritual, religious and secular, scientific and humanistic, rural and urban, tribal and 'modern', bourgeois and proletarian, and so on. This sort of classification, although helpful in a limited way, overlooks many rich complexities of cultural life. For example, when we closely look into the basic human ends as conceived in the Hindu tradition, *puruṣārthas*—*dharma*, *artha*, *kāma*, and *mokṣa*, it is not difficult to realise that this broad spectrum of values contain both material and spiritual elements in it. Similarly, it is not easy to draw a sharp line of division between the religious and the secular. The disturbing ambiguity of the terms apart, one may raise the question whether the State must be indifferent to, or equidistant from, or equally tolerant of the groups

of people professing different religious faiths. The other relevant questions in our context are whether these concepts are purely modern and normative or were they present in the past and in a normative way.

The so-called division between scientific culture and humanistic culture is under attack right from the days of ancient thinkers, both in India and Greece, defending the concepts of orderliness, *ṛta*, and *number* in all possible domains of experience, from cosmology to music and mathematics. One finds in India that even scientific and mathematical treatises have been written in verse. It is not surprising that in our tradition the words *kavi* (poet) and *dārsanika* (philosopher) are often used as synonyms.

In the fast changing economic context of today, the rural-urban division seems to be on the decline. Given the current trend of urbanization and industrialization, the received concept of tribal culture is also likely to be under strain. Under the developing economic and technological conditions, the steady rise of consumerism and embourgeoisment of values may not leave what is called proletarian culture untouched.

The inadequacy of the taxonomy of culture is very strongly felt perhaps in the field of fine arts like dance, music, painting and literature. It is interesting to note that literature, which in a way is a part of culture, seems to 'reflect' the whole of it. Fine in temper and texture, fine arts, one feels, capture the spirit of history (*yugadharma*) in a very refined way.

To find out the right place for the works of the finest artisans raises an interesting problem. Are they to be regarded artistic or merely useful? Are not some of the very *useful* objects of life extremely *beautiful* as well? Elegantly formulable and mathematisable, a major part of so-called hard sciences is indeed *simple* and beautiful. Seemingly puzzling, this question of culture, viewed in its appropriate structural context, is soluble and intelligible. This does not entail any sort of radical relativism and sentimentalism.

The scenario outside fine arts seems to be less problematic. It is true that sociology, anthropology, economics and jurisprudence may be viewed both positively or value-neutrally and normatively. In all these disciplines history and descriptive details have, or at least should be allowed to have, an important say. In a way this approach contributes to objectivity, keeps values close to facts and avoids the extremes of ideologization of facts and factualization of ideals or values. While the separation of facts and values is untenable from the historian's point of view, over-emphasis on the one to the total disregard of the other may lead either to crass fact-fetishism or romanticization of the *really* lived past. Admittedly, the historian, otherwise free to select facts in the light of his hypothesis from the boundless plenum

or continuum of details, is always under obligation to check and recheck his view against the reasonably determinate facts. One need not enter here into the epistemological issue whether facts themselves are incurably theory-loaded and therefore bound to remain more or less indeterminable.

The main aim of this Project is to review the past of India in the light of researches and findings available at present. This may rightly appear too general a statement to clarify the said aim. Of course, history in a way has to be contemporaneous. But when we are updating history, the characteristics of the past, of the past ways of living of the vanished generations, must be kept in view. Otherwise, it is rightly apprehended, attempts may be made to translate everything of the past—ideas, outlooks, attitudes, modes of actions, and world-views of the concerned peoples, marked by their specific characteristics, into their 'corresponding' modern idioms. This reductionistic modernism is bound to take away the specificity, beauty and use of history. For example, if the astronomical ideas of the Vedic time are sought to be accommodated within the framework of the currently accepted astronomical theories, we do not do justice either to the keen observers of nature of the ancient time or to the contemporary astronomers.

Simply because the old scientific theories have been falsified by subsequent findings and superseded by new and more developed theories it would be obviously wrong to suppose that the former are of no *historical* use or interest to us. On the contrary, it is precisely from the history of outdated science that the updated science emerges. Similarly, it is out of the past ways of living that the modern ones evolve. And since this story is continuous, it would be height of ego-centrism on our part to suppose that we are living in a *privileged* present.

We have no right or reason to think that we are standing on the precipice of time and that beyond us there will be no history. Obviously, this is counter-intuitive. More or less conscious of the past, we live in the present, and, rightly understood, work as architects of the future history. Strictly speaking, these segments of history, past, present and future, rooted in customary classification, is purely metaphorical.

The Project we are working on is not only an exercise in capturing the past of India but also to understand the spirit or trends of the present. What is more, we are objectively obliged to work and plan for the future. Our perspectives, both theoretical and practical, have in them the legacy of history, the imprint of the present and hope of the future. In an important way this Project is bound to be futuristic in its orientation.

Where, then, does its focus and newness lie? What are the threads which bind together different disciplines of the Project? In our preliminary

observations it has been pointed out that the division between different disciplines and the supposed boundary lines between them are more conventional than objectively warranted. Making due allowance to the conventionally drawn distinction between science, art, technology and their different forms, we are trying to highlight the points of their commonality. Until recently only compartmentalized works were available on different areas of knowledge, for example, on the history of politics, history of science, history of philosophy and history of culture. Later on a few notable attempts have been made to present an interdisciplinary account of some branches of knowledge. But to the best of our knowledge, no comprehensive work is there on the history of science and technology, society and polity, together with their cultural context and concomitant forms. Here we are trying to show how the different facets of culture are causally interwoven and interactive. We are aware that this undertaking is not only comprehensive but also extremely difficult. That is why we have tried to get distinguished scholars drawn from different disciplines involved in this enterprise. Moreover, when we describe this academic venture as a Research *Project* what we mean is this: it cannot be executed in a fully satisfactory, still less complete, way in one single attempt. More scholars, more ideas and time are in need. Readers of the publications of this Project (PHISPC) are cordially invited to join it as collaborator, critic or in some other fruitful manner.

In fact this Project has been taking shape through interplay of ideas and critical interactions between the scholars working on it. Therefore, it will be found that there is no partisan ideology, official or unofficial, underlying the works of different authors. Of course as free citizens and in their *individual* capacity they are free to have their own ideological preferences. The basic unifying factor of PHISPC is critical and reflective interrogation of different views, values and facts defended and referred to by different writers. The other unifying force of it, as indicated before, is its interdisciplinarity. Within this framework, different writers are free to express their views consistently with their preferred values and intellectual commitments.

Perusal of the papers included in the Volume will show different points of view, diverse orientations and difference of emphasis. For example, G.C. Pande ('Culture and Cultures') though refers to the scientific and the historical approaches to culture, explains in detail his own preference for the metaphysical approach and also offers the grounds of his preference. He painstakingly tries to show how the material, scientific and technological expressions are interlinked between themselves and rooted in human nature; and the latter itself in turn is transcendently affiliated. In his

perception, values form the matrix of the material forms of life. The unity of human nature and the ideal of culture are reconciled by some pervasive axiological principle.

The essential character of human nature is said to be free and its expression is bound to be pluralistic. There is some universal thread which runs through all forms of expressions of culture, material as well as spiritual. In relation to their environment human beings are unmistakably the masters or dominant. But this power, Pande observes, 'has not given [man] a comparable power over his own social and cultural environment'. To him, the real question about the form of culture pertains to its 'meaningfulness and authenticity not its efficiency, nor . . . sheer facticity'. Value-fact dichotomy seems to be untenable. The juxtaposed characterization of 'material civilization' and 'spiritual values' also appear to be misleading. Culture is a pervasive moral order. It binds society and civilization together, provides them a character and direction. Shaped by traditional wisdom, it is through culture as value that free human beings make use of material objects, ideas, and ideals to shape their intended future.

Unlike Pande, Sen [*'History of Science in Relation to Philosophy and Culture in Indian Civilization'*] seems to prefer the historical method in studying the relationship between science (including technology), philosophy and culture. To be more specific, he wants to follow it from within. To grasp it in perspective, he maintains, 'it is necessary to explore the Indian understanding of, and attitude to, science over the ages and their conscious appreciation . . . of the relationship of this science with other activities . . . philosophical, social, economic . . . which taken together constituted their culture'. This reflective-historical approach is based on a particular definition of science, namely, 'system of behaviour by which man acquires mastery of his environment'. It is apparent that knowledge and skills, science and technology, are included within this 'behavioural' system. Sen, himself a professional physicist, considers the distinction between science and technology 'superficial'. While in the so-called pre-scientific age the relevance of technology to science was dominantly articulate, later on their positions got reversed. Science started appearing as the dominant partner. However, the interplay between the two continues. Both emerge out and are expressive of our different forms of life.

To illustrate the point of social origin of science, Sen refers to two proto-historical civilizations, the Bronze Age civilization of the Indus Valley and the Vedic civilization. Besides agriculture and irrigation, fibres and fabrics, specific reference is made to metals and metallurgy which had appeared in Iran around the fifty-fourth millennium BC; the same found their way to

India after about thousand years. From Kalibangan and other pre-Harappan sites the archaeologist has found a rich collection of various sorts, knives, razors, chisels, arrow-heads, axes, fish-hooks, true saws, pots and pans. Relying on contemporary theory and evidence, Sen veers round to the conclusion that India had at least four distinct iron-using centres whose age varies from 700 BC to 1500 BC. Interestingly enough, he points out that the technological efficiency which depends to a large extent on the development of adequate system of weights and measures and consequent standardization, was available to the people of Indus valley civilization. It is equally interesting to note that the sciences which developed at that time were primarily practical like geometry, medicine and astronomy. For the purpose the rich language that was necessary was provided by what has been called 'Vedic Sanskrit' or 'Ancient High Indian' (Winternitz).

It is clear that the Vedic people were keen observers of nature and worshippers of the powers and the forces of nature. Thus human relationship with nature was many-sided, cognitive, affective, theoretical and practical. The Vedic poets had in them unmistakable cosmological insights. The law-governed and predictable character of the heavenly bodies was also known to them to a considerable extent. The principle of *ṛta* or orderliness was perceived to be present and operative both in the heavens and on the earth (including the human life).

The basic inputs which philosophy provided to the scientific and social enterprises of the time are to be found in its conceptions of valid knowledge (*pramā*) and the means (*pramāṇas*) which make it (*pramā*) possible. In terms of their views on matter, life, substance, atom, motion and evolution, philosophy influenced science. The science-philosophy demarcation was not sharp at that time. This has been illustrated by the *speculative* origin of science in all ancient civilizations. The mutual relationship between the civilizations of India, Egypt and Mesopotamia and their fundamental ideas, discoveries and inventions is well established. At the same time the discerning historians like Gordon Childe could justifiably assert that India produced 'a thoroughly individual and independent civilization of her own, technically the peer of the rest'. Sen substantially endorses this view. But this historical evaluation, admittedly a matter of pride, should not be taken as a plea for Indo-centrism, an unfortunate oriental response to equally unfortunate Eurocentrism.

The relation of metal technology with the Indian Bronze Age cultures to which Sen has made brief but pointed reference has been discussed in depth and details by Agarwal ('The Indian Bronze Age Cultures and Their Metal Technology'). Copper technology was available in India from the Third

to the early First Millennium BC. Together with copper, stone was also in use. The socio-economic evolution of different cultures was neither unified nor unilinear. The peoples of the Harappa, the Banas, the Kayatha, the Malwa, and the Jorwe cultures used both copper and stone. The Chalcolithic cultures were non-urban and their economy was kindred in character to the non-metal-using Neolithic cultures of the Deccan. In the field of art the Harappans do not appear to have developed much; but the surviving archaeological findings clearly suggest their mastery of the plastic art. The plastic rendering of the Kalibangan terracotta heads seems to be more lively than that of Mohenjodaro and appears to be exquisite in its execution.

The first phase of Indian urbanisation started in the Third Millennium BC. It was supported by the mid-Holocene climatic conditions, abundant availability of metal minerals and copper technology, irrigation technology, agricultural surplus, internal and external trade. Most of these urban sites understandably developed around the alluvial plains of the Indus and the Saraswati rivers. Several copper- and stone-using cultures came into existence in the Second Millennium BC. Most of these cultures, barring the Harappan culture, were apparently non-urban. Copper technology alone was not enough to ensure the development of urban culture. The ecological constraints like dense tropical forests, rocky or not-so-fertile soil conditions worked as negative factors and proved obstructive. With their inefficient copper implements the people of the time could not make much progress towards urbanisation. Though the proto-historic cultures spread over the areas now known as Uttar Pradesh, Madhya Pradesh and Maharashtra were more or less contemporaneous, they were not in functional contact with one another. Their ethnic composition was understandably mixed because of the successive waves of Indo-Aryan arrivals. The copper technologies available to them were also uneven in character. For their full-fledged colonization and subsequent urbanisation, observes Agrawal, they 'had to await the advent of iron'.

That for calculation or computation, classification or taxonomy, standardization and prediction we need mathematical knowledge has already been referred to by Sen and Agrawal. For such practical activities as town planning and metallurgy, especially for alloying different metals for different purposes, mathematics had been of extensive use. Ethnomathematics, a newly developed branch of mathematics, highlights the human relevance and practical use of this otherwise abstract branch of knowledge. Even for the purpose of reciting the Vedic hymns one was expected to have a sense of metrical rhythm.

The Veda which is believed to be the oldest and most authentic reposi-

tory of knowledge in India has in it the elements both of abstract-theoretical and concrete-practical ideas. The ideas underlying such ritual activities as *yajña* as well as astrological and astronomical pursuits like calculating the place and movement of the celestial bodies are found in the Vedic *mantras*. *Mantra* is poetic speech, invested with the intensity of rhythmic movement, the intensity of interwoven verbal form and thought-substance and the intensity of the human vision of truth. Mystic and symbolic in character, the Vedic poetry is claimed to be the expression of the two planes, physical and psychical of one and the same universe (Kireet Joshi, 'Significance of the Veda in the Context of Indian Religion and Spirituality'). Though the ultimate reality is one but it is said to be many. This well-known verse of the *Rgveda* [*Rv.* I.164.46.] anticipates different possible interpretations of the statements about the same truth. In fact Yaska himself has spoken of several schools of interpretation of the Vedas. This hermeneutic pluralism is ontologically rooted. This may be looked at from two different ends, the natural and the spiritual. The spiritual may be taken as meant by the natural; and the natural as the expression of the spiritual.

The Vedas have different meanings. To start with, the Vedas meant only the four Vedas, *Rk*, *Sāma*, *Yaju* and *Atharva*. Later on the Upaniṣads also came to be regarded as part of the Vedas. Actually, Vedāṅgas, viz., *śikṣā* (phonetics), *kalpa* (ritualogy), *vyākaraṇa* (grammar), *nirukta* (etymology), *chanda* (metrics) and *jyotiḥ* (astronomy and astrology), had begun to develop even before the Upaniṣads. Apart from the Vedāṅgas there developed four Upavedas viz., *Āyurveda*, *Dhanurveda*, *Gandharvaveda* and *Arthaveda*. In the extended sense, Vedas include even the two epics, *Rāmāyaṇa* and *Mahābhārata*. A vast literature of expositions, commentaries and treatises on the Vedas, Vedāṅgas and the Upavedas developed in due course. The many-sidedness of the Indian tradition may be gathered from this rich literature.

In this tradition, spirituality is rated above religiosity. Psychological discipline, *Yoga*, provides access to higher spiritual experience. 'This allowed intellectuality', observes Joshi, 'to become free from the crippling effects of religious dogma'. Materialistic atheism, agnosticism and even scepticism were allowed to develop. But undoubtedly the Vedic-Purāṇic emphasis was more on pure existence, *sat* (*satyaloka*), *cit* (*tapoloka*), pure bliss, *ānanda* (*janaloka*) and knowledge, *vijñāna* (*maharloka*), in that order. It is true that other three principles, viz., mind (*swar*), life (*bhuvā*) and matter (*bhūr*) are recognized by the Vedic-Purāṇic tradition, but they are accorded a lesser status, i.e. less developed states of reality. Some commentators are of the view that this graded ontology accounts for the critical

attitude of the received Vedic tradition towards life-affirming claims of vitalism and materialism. Sri Aurobindo himself, to whom Joshi owes a lot, extensively refers to this aspect of Indian tradition.

Although there is a point in Joshi's claim that Vedic tradition is marked by an element of catholicity, it can hardly be denied that in the early middle ages much of this catholicity was practically forgotten. That at least partly accounts for the rise and acceptance of Buddhism in India. Another point which perhaps deserves mention here is that often exaggerated and uncritical claims have been made by even otherwise well-meaning traditional scholars. To love and respect one's culture does not require one to be unmindful of its blemishes or dead aspects.

This point has been raised by Narlikar ('Four Questions That History Might Answer') in the specific context of the scientific content of the Vedas. In particular he closely looks into the astronomical ideas to be found in the ancient writings. He critically refers to the 'very sweeping statement that all important discoveries of modern science are to be found in the Vedas'. Also critical is his reference to 'the so-called Vedic mathematics' and 'sophisticated (technology of) guided missiles (to be found) in the *Rāmāyaṇa* and *Mahābhārata*'. In our anxiety to appear at par with the west we must not be tempted to glorify our past disregarding the objective facts of history and romantically interpreting the same. The scholars of history in general, and those of history of science in particular, are expected to rise above highly subjective pride and prejudices and 'objectively assess whatever information that can be gleaned from the ancient literature'.

The four questions which have been specifically raised by Narlikar inviting the historians to answer are: (i) what is the scientific content of the Vedas? (ii) Can astronomical allusions be used to date ancient writings? (iii) Were any *super novae* observed in India during the Siddhāntic Period? and (iv) Why did scientific activity decline after the Siddhāntic Period? Sometimes questions are as important as the attempted answers. In science answers are meant to solve problems or remove anomalies or puzzles. The main importance of Narlikar's questions lies in the author's appeal to the critical spirit of the historians so that they remain committed to their scientific temper and are not swayed away by unfounded patriotism. To him the Vedic mathematics appears 'like a compendium of methods of quick calculations'. The essentials of higher mathematics like number theory, higher algebra, topology, analysis and algebraic geometry are not to be found in Vedic mathematics. It is clear that Narlikar's is an open mind. Obviously he is more interested in knowing the scientific content of the

Vedas from the Vedic scholars and not in summarily rejecting the claims alluded to in the ancient writings.

Narlikar, a professional astronomer, feels intrigued by the non-availability of the record about the possible observation on 4 July, AD 1054 of the Crab Nebula by the Indian astronomers. Because this Nebula is so well known to astronomers and it was actually seen and recorded by the astronomers of China and Japan at that time. It also appears surprising that it happened during the flourishing Siddhāntic Period of Indian astronomy, from Āryabhaṭṭa in the fifth century to Bhāskara II in the twelfth century. Narlikar's conjecture is that this non-availability is due to excessive reliance on oral tradition. Other factors to which he attributes the decline of scientific activity after the Siddhāntic Period are absence of climatic challenge, non-existence of motivation towards applied science and technology, and the non-availability of royal patronage. It is argued that the benign tropical climate of our country could not bring out the best that was there in our ancestors. By contrast the challenge of the wintry conditions of Europe prompted its people to work hard both practically and theoretically. Further, the life-affirming attitude of the peoples in Europe, their social values and educational system fostered and sustained in them a spirit of enquiry. The establishment of universities at Bologna, Padua, Oxford, Cambridge, Paris and other places and the invention of printing technology at the Netherlands provided commendable impetus to the growth of science in Europe. The learned bodies like the Royal Society and the French Academy functioning under the royal patronage also contributed significantly for the promotion of science. Comparable patronage, it is said, was not provided by the rulers in India. Their patronage was extended mainly to arts and architecture. Under the circumstances to be an original thinker like Āryabhaṭṭa or Bhāskara one had to be extremely inspired and exceptionally motivated.

Whether the above account is correct and comprehensive enough to be accepted in its entirety may be debatable. But the questions raised and the causes of the decline of science in India during the medieval period undoubtedly deserve careful and deep examination. In the process we are expected to have new ideas and insights.

In the Indian tradition knowledge has been broadly divided into two types—*aparāvidyā*, empirical or mundane knowledge and *parāvidyā*, superior or spiritual knowledge. The former was meant to help humans in their material needs and scientific pursuits, and the latter for the attainment of self-knowledge. Both types of knowledge require us to perform some activities, *nitya* (perpetual) and *kāmya* (optional for end-realization). For example,

those who desire heaven are expected to construct falcon-shaped altar because a falcon flies best among the birds (*Rgveda* 1.15.12). This sort of practices, scientific or superstitious, contributed to the growth of geometry and mathematics in India. Bag tries to show that development of formal sciences has very intimate relations with the regular forms and features of our life ('Mathematical and Astronomical Heritage of India'). For example people like to know the right time for performing religious activities, observing rituals, undertaking agricultural activities and recording of recurrence of repeated events from seasons, stars, movement of planets and other celestial bodies. In the Vedic tradition *gaṇita* and *jyotiṣa* are regarded as closely related because of their essential computational character. It is to be remembered that apart from the Vedic schools referred to by Varāhamihir there were other schools, including those of Jainas and Buddhists, who specialized in mathematics and astronomy. Geometrical systems, *śulbasūtras*, of Baudhāyana, Āpastamba and Kātyāyana are particularly important for their precision and rigour. Baudhāyana gives various units of linear measurements and had knowledge of square, rectangle, triangle, circle, and various other diagrams and transformation of one figure into another and *vice versa*. The relevance of geometrical principles to architecture is clear. It seems that the *śulbasūtra* tradition vanished with the passage of time.

It is true as pointed out by Narlikar that many of the modern developments of mathematics, understandably, are not to be found in ancient India. But it is important to note Sarton's observation that our numerals and the use of zero are due to the Hindus and transmitted to Europe by the Arabs. In fact what pass for Arabic numerals now are, historically speaking, Hindu numerals. Initially there was only three-tier system of word numerals. Later on numerical symbols began to appear. In the *Mahābhārata* [III.132–34] it has been said that the signs of calculation are always only nine in number. But Pāṇini [450 BC] used the word *lopa* and Patañjali the word *śūnya* in the context of metrical calculation. The Arabs took it over as *aṣ-ṣifr* and later on in Italy it changed to *zefiro*. To start with, the number system was additive and did not use decimal scale. Further numerical symbols were many and it prove difficult to decipher the correct meaning. Perhaps the Jaina thinkers tried to achieve a synthesis of the Vedic decimal system with the prevalent situation of the time. The numerals are described as *aṅka* and decimal scale as decimal places. And their numeral vocabulary was similar to that of the Brahmanic literature.

Besides land survey, altar construction and determining the seasons of sowing and harvesting, the areas in which mathematical knowledge proved very useful are naming and identifying the stars near moon and with refer-

ence to it, ascertaining the path followed by moon, sun and the planets, and dividing it day-wise. It was found that the moon takes more than 27 days but less than 28 days to return to the same position. The lunar month was measured from full-moon to full-moon or from new-moon to new-moon. It is from the experience of regular and periodic recurrence of climatic seasons that the means of measuring a year originated. The concepts of *muhūrta*, *yuga*, *kalpa* and *mahāyuga* are among the notable contributions of Indian astrology and astronomy. A large number of astronomical instruments were known to and used by the Indian astronomers and their names are available from the concerned literature.

History of a culture may be traced in very many ways, scientifically, i.e. from the standpoint of the working scientist, technologically, archaeologically, and philosophically. This is not to suggest that these approaches are necessarily exclusive. On the contrary, the grounds covered by different historiographies have their natural interface and many of their points are bound to be common. They differ mainly in their emphasis and orientation. The concepts they bring to bear upon their materials are understandably different. For example, when Rao writes on the history of science in India, he approaches the subject matter from the standpoint of an archaeologist ('Scientific Tradition in India 3400–1500 BC'). Naturally he touches upon many points covered by Sen and Bag. But, because of his archaeological background and its broad scope, he brings in his presentation certain points which are central to the contributions of other writers as well.

While discussing the Harappan Civilization he observes that the Harappans were pioneers in studying tidal waves and currents and utilized their knowledge to build the first tidal dock of the world at Lothal. Certainly it contributed to maritime activities of the people. The far flung sea trade of the Indus civilization with the Persian Gulf countries, Mesopotamia (Iraq), Elam (Iran) and Syria, gave rise to the establishment of merchant colonies. Not only merchandise but also ideas used to be exchanged in those colonies. High sea navigation and even coastal navigation required familiarity with the elements of astronomy and hydrology.

Also in their town planning is evident their knowledge of the science of hydrology enabling them to keep their cities and town meticulously clean. The astronomical knowledge of the Harappans can be inferred from many of their seal inscriptions. Rao conjectures that the Harappan *gavāmayana* was perhaps a symbolic way of keeping count of the days and months and adjusting the lunar calendar of 350 days to the solar calendar of 365 days. Besides astronomical knowledge and marine engineering Rao credits the Harappans for developing the science of yoga. Apparently they succeed-

ed in bringing about the cultural integration of fire-worship and animal-worship groups. This hypothesis is based on the evidence of the composite animal deities engraved on seals.

However, 'the greatest contribution of the Harappans to human progress' according to Rao, 'is the invention of an alphabetic system of writing by simplifying a partly pictographic script by dropping pictures and using simple cursive signs are similar to many of the Semitic alphabet. Both are more or less contemporary.' By disciplining a partly pictorial script into a simple alphabetical writing the Harappans facilitated the cultural process of quick recording and easy communication of ideas. Rao provides few examples of the Harappan techniques of writing in simplified form and the method of decoding the script.

The historiographical tone of Rao's presentation is optimistic. He does not share the general assumption that a dark age descended on India after the decline of Indus cities. In this connection he specifically refers to the discovery of the great port city of Dvaraka of Gujarat coast. The basic foundation of the Indian civilization and scientific thought is claimed to have been laid by the Harappans. Certainly this view deserves further consideration and follow-up research.

To study history is to study tradition. But all traditions are not alike. Some are backward-looking and conservative; some are interested in preserving the received wisdom of the past and prompting the concerned people to act accordingly; and some are forward-looking and motivate people to research for breaking the present frontiers of knowledge. Scientific tradition comes under the third category. The scientist is primarily interested in tackling and if possible solving the existing problems and discovering new truths. Obviously the philosophical, religious and other traditions which try to prove that whatever we have received from the past is pure, uncontaminated by new-fangled ideas and therefore more dependable, tend to convert us to orthodoxy. 'Whatever is traditional is rational' seems to be the motto of this attitude. It is clear that *all* traditions do not fit in these two clear-cut slots. Most traditions are mixed, partly backward-looking, partly conservative in the constructive sense, and partly imbued with some or other forward-looking ideology.

In his presentation ('Scientific Tradition and Other Traditions') Udgaoonkar closely looks into the relation between the contrary pushes and pulls of different traditions obtained in India. That India had a rich scientific tradition and which survived for a long period, say, up to AD 1200 is not ordinarily disputed. The question which interests many of us is why India could not sustain its scientific and technological growth in the second

millenium AD. In fact Udgaonkar's question on the matter is somewhat similar to Narlikar's. Clearly respectful to and yet critical of our cultural heritage, Udgaonkar is in favour of studying this question in an unprejudiced manner. It is true that not only India but also China and the Arab world could not carry forward their early achievements. It is of no use only to debunk the ill-founded theories of western scholars on the issue. We need to be self-critical on our own. It is not enough to reject the patently prejudiced accounts of Hegel and James Mill or merely to highlight the shortcomings of the views of William Jones, Colebrook, Wilson, and Max Müller. Nor can the admirable scholarship of Sarton, Farrington, Bernal and even Needham, help us much unless we ourselves are prepared to *examine* critically our cultural heritage with a definite, truly interdisciplinary and objective outlook. Internal criticism, all things being equal, is likely to be more informed and instructive.

Udgaonkar very pertinently looks into the logic and meaning of such concepts as *māyā* or 'illusion', *parāvidyā* or 'higher knowledge' and *aparāvidyā* or 'ordinary knowledge', the *karma* ideology, and the *bhaktimārga*. These ideas and ideals are often held to be responsible for arresting the development of science and technology in India. Pointedly referring to Vivekananda, an uncompromising Vedantin, Udgaonkar tries to show that the doctrine of *māyā* has been widely misunderstood. *Māyā* is not illusion in the received sense. It does not mean that the physical world is unreal or unimportant. It only means that there are other levels of knowledge beyond the natural sciences. Pursuit of 'principles' does not entail denial of earthly 'details'. From *Atharva Veda* to *Carakasamhitā*, from *Arthaveda* to *Arthaśāstra*, from *Rgveda* to *Kāmasūtra*, one finds an amazing range of Indian views and values, a remarkable blend of principles and details. Udgaonkar finds in Vivekananda a link between ancient tradition (rather, the *Advaita* tradition) and modernity. If scientific method requires that the 'principles' of science have to be consistent with and, preferably, tested by empirical 'details', the Vedantic approach as defended by Vivekananda seems scientific to Udgaonkar. Earlier, B.N. Datta, a Marxist sociologist and younger brother of Vivekananda, found elements of Marxism, ideals of patriotism and power of ideological prophecy in him. In this connection, Udgaonkar refers also to Jawaharlal Nehru and Romila Thapar, who in different ways, affirmed *this-worldly* characteristics of Indian culture.

In this controversial context one may recall Sri Aurobindo, a follower of Vivekananda in his early life, who criticizes at length and rejects 'illusionism' of Sankara. But he claims that the traditional *puruṣārthas*, *dharma*, *artha*, *kāma* and *mokṣa*, prove the integral and *this-worldly* character of Indian

culture. Many leaders of the Indian Renaissance and freedom movement, from Rammohun, Rabindranath, Tilak and Vivekananda to Gandhi and Binoba Bhave were both deeply religious and strongly anti-imperialist in their disposition and action. Spiritual tradition does not necessarily make the people indifferent to political and economic issues. Nor does it always downgrade the spirit of scientific inquiry. Another influential view, painstakingly argued by Debiprasad Chattopadhyaya, an outstanding Marxist scholar, that systematic suppression of materialistic ideologies in ancient India adversely affected the promising growth of Indian medicine appears flawed to Udgaonkar. To illustrate the point that theology-related counter-ideology cannot always effectively suppress science, he refers to the burning at the stake of non-conformist thinkers like Giordano Bruno and the trial and humiliation of Galileo. Even in the face of counter-ideology, given other favourable conditions, science and technology may possibly grow. It is well known that many scientists of eminence in India and elsewhere were found to be deeply religious in their mind. Theoretical pursuits and religious convictions are not always convergent or even consistent. What *seems* to be strange is that, Newton, knowing fully well that Whiston is a dogmatic Christian and believer in the infallibility of the Scriptures, found nothing wrong in getting him elected as his successor to the chair of Lucasian Professor of Mathematics at Cambridge. What it implies is this. One's professed religion or ideology is not *causally* related to and reflected in one's intellectual excellence and practice.

The main enemy of science and scientific growth seems to be dogmatism, self-righteousness and indifference to the achievements of other civilizations. Self-imposed isolation of the thinkers and scientists of India adversely affected their intellectual progress. Another factor which stifled the development of science in India was the growing rigidity of the caste system resulting in the separation of intellectual work from manual work. Philosophers started neglecting empirical facts. Scientists became indifferent to the practical application and test of their principles. Also the gradual decline of the *public* availability of the best forms of knowledge and skills and confinement of the same to *guru-śiṣya-paramparā*, familial tradition, appear to have negatively affected science, philosophy and technology in our country. The growing separation between the literati and the laity that was taking place here was bound to weaken and darken the ground of knowledge and also to dim the brightness of light at the top. The rise and fall of science and philosophy, broadly speaking, are determined by two related sets of conditions, internal and external, internal socio-economic conditions and external contacts. Both have to be duly taken into account

in order to correctly understand our scientific tradition, philosophical past and cultural heritage. Udgaonkar's scholarly contribution is sure to trigger off instructive controversy.

As indicated earlier, no abstract scientific discipline, not even mathematics, is unrelated to our life-experience. But some forms of science like chemistry and alchemy stand particularly close to our practical life. The point has been persuasively argued in details in her scholarly contribution by Deshpande ('History of Chemistry and Alchemy in India from Prehistoric to Premodern Times'). The principles of chemistry are related to the use of various articles of our daily life. Pottery, bricks and metal wares, for example, required the application of the principles of chemistry to practice. Also it was of immense use to metallurgy in producing such alloys like bronze, brass and bell-metal. For production of different types of iron for diverse purposes people needed knowledge of chemistry. Chemical arts and crafts, originated in the pre-historic and the ancient Vedic times, developed further in the medieval period. The late medieval period witnessed the rise of alchemy together with its theoretical and experimental aspects. The philosophical principles underlying chemistry and alchemy are also unmistakable. This is evident, besides the classical *Sāṃkhya-Yoga* system, from such works as *Rasaratnākara* of Nāgārjuna, *Rasārṇava*, and *Rasārṇvakalpa*. So far chemistry and alchemy are concerned it would be wrong to think that the medieval history of science in India was dark. Apparently this admirable period came to a standstill around the seventeenth century. Later on towards the end of the nineteenth century, mainly due to the impact of modern chemistry and other sciences of western origin, chemistry started gaining independent recognition, academic respectability and technological popularity.

The basic elements of the history of Indian chemistry are generally culled out of three main sources, viz., archaeological findings, literary records, and the study of traditionally available techniques. The materials available from the history of Indian chemistry have been viewed under four general heads—from pre-historic to pre-tantric period (up to AD 600), chemical arts and crafts, history of alchemy and the later development. In this field pioneering work of P.C. Ray has been ably followed up by gifted scholars like P. Roy, B.V. Subbarayappa and their colleagues.

Pure or distilled scientific theory is not what we readily arrive at. As promise of history remains there concealed in protohistory and even in prehistory, science is *influenced* by protoscience like metaphysics and even prescience like myth/mythology. The customary distinction between pre-science-protoscience-science is merely suggestive and somewhat arbitrary

like that between the ancient history, the medieval history and the modern history. Most of the historiographers themselves admit that periodization of history, local or national, scientific or humanistic (discipline-wise), is a very tricky affair. It is very difficult, almost impossible, to state clearly where, when and how one period ends and another begins. Since history is not a formal discipline like geometry or arithmetic, the historian is not expected to work with a well-defined vocabulary; for him ordinary language is good enough. Even then the main reasons for which he advisedly draws a line of distinction, for example, between prehistory-protohistory-history are to separate the separable on the ground of varying reliability of available evidence, to avoid the misgivings associated with reductionism, and thereby to minimize confusion. For analogous considerations the historian of chemistry even while he draws the distinction between chemistry and alchemy does not fail to point out their substantive continuity.

Similarly, the historian of science, if he happens to be a reductionist, highlights the reducibility (of laws) of chemistry into (those of) physics. Both the sciences in a way are concerned with the properties, composition, and structure of matter. It has not been found easy in the western tradition to ascertain when exactly chemistry as an independent science came into existence. But conventionally Lavoisier's correct interpretation of combustion (1774) is taken to be the 'end' of alchemy and the beginning of chemistry.

The theorists of chemistry/alchemy in the Indian tradition, more or less like their western counterparts, believed in five basic elements (*bhūtas*) of nature (*prakṛti*). Empedocles spoke of four elements, earth, air, water and fire, and Aristotle supposed the heavens to consist of *aether*. The five elements of the Indian tradition are *ksiti*, *ap*, *tej*, *marut*, and *vyom*. The followers of the *Sāṃkhya* system believe that three constituent properties, *sattva*, *rajas*, *tamas*, are present in every element in various combination. In his philosophical presentation ('Spreading of the (Al) Chemical Myth (Word): Scientific Explanation, Historiography of Indian Chemistry, and History of Philosophy') Basu tries to show, among other things, how close chemistry stands to physics, different medicinal uses of chemistry and how the Indian theories of atomism and of causation were used by the writers on alchemy/chemistry. In alchemy one finds a lot of symbolism of spiritual kind. The alchemist subscribed to an organic view of nature in which no meaningful distinction between the animate and the inanimate could be drawn. In fact nature was viewed by him as psychic. More comprehensively speaking, human being (a microcosm) was viewed as an epitome or consummation of the universe (macrocosm) as a whole.

The Indian alchemic tradition was aligned to the tantric way of life. To reach the Divine through the practice of yoga, *kāyasādhana* or *kāyakaḥ*, was recognized as extremely important. Another important aspect of alchemy was *rasa* therapy. In the *Rasa Śāstra* the use of mineral drugs, especially mercury and sulphur, is recognised. By *māraṇa* process the drugs of mineral origins used to be converted into a fine ash form for systematic absorption. The alchemist discussed in depth the properties of mercury and sulphur. The union of mercury and sulphur was deemed to be a mythological analogy of the union between *Śiva* and *Pārvatī*. To sulphur was attributed superior therapeutic *rasāyana* property.

From the standpoint of philosophy or scientific method the more fundamental question is how by deciphering this type of analogies we can, if at all, get a clear idea about the ascertainable cause or causes of different *rasas* used for different practical purposes, technological, metallurgical and medical. Is there a universal cause of all types of *rasas* and, if so, does it work under different conditions producing quite different or unlike effects? Basu feels that in the traditional chemical/alchemical thought in India there is a confusion regarding final cause and immediate material cause. He feels the concept of universal/final cause can hardly be defended in the practical context of *rasāyana* and for metallurgical-transformational or medical-healing purposes.

Basu is against what he calls the presentist historiography of chemistry as practised in India. What he means in this. It will not be advisable for the historians of chemistry of to-day to rely mainly on the contemporary concepts of chemistry and to try to understand the past concepts of alchemy/chemistry in terms of the same. While in a sense history is bound to be contemporaneous, the historian has a definite obligation to get into the meanings of the ideas and practices followed by the past thinkers on the subject.

In this connection his reference to the role of history and of philosophy in the specific context of chemistry in India seems to be interesting. On his own admission, though he has not gone deep into the matter, he suggests that the philosopher of science may be benefited by looking closely into the history of science. The task of the philosopher is primarily to clarify the fundamental concepts and questions of science bearing their historical context in mind (and *not* in an abstract way). Historically speaking, it appears to Basu that the alchemist in India perhaps 'viewed their work in the tradition of elaborating a *prayajana śāstra* without feeling the need for developing any methodological prescription which would be philosophically defensible'.

Is not this 'shortcoming' evident in the works of many good and even

great scientists? Has it been said of the great Newton that his observations on his own methodology, especially those with reference to the role of hypothesis, *hypothesis non fingo*, are rather naive? In the history of science rarely we come across the greatness of an Einstein who could successfully combine in him scientific genius with correct philosophical insights. Perhaps this criticism may be extended to the historians themselves who are ordinarily found to be more or less 'presentist'. What about philosophers writing on the history of their own discipline? Can a Madhvācārya or Hegel be totally impersonal or objective while writing about other philosophers' views? Perhaps in search of a plausible answer to these questions the philosophers, scientists and historians are required to interact more intensively and, if possible, in a better informed way.

Problems of contrary types are at work in the field of history of science, philosophy and culture in India. If some of us, intimately familiar with a specialized and contemporary branch of knowledge, exhibit 'presentist tendency', some others among us, more versed in classical scholarship, are inclined to take a justificationist attitude towards the past. But it would be unfair to forget that there are many historians who have reconciled their specialization with classical scholarship. Still some difficulties are often encountered. Not a few of our working scientists, philosopher and historians live a double life, professionally rational and privately superstitious. Professional integrity and personal integrity cannot be neatly separated. When a learned person, whatever might be his area of specialization, tamely submits to a fictitious authority under some influence or other, the excellence of his work is most likely to be compromised.

On this important and sensitive issue Debiprasad Chattopadhyaya ('Methodology: On Self-criticism'), Bhargava and Chakrabarti ('The Scientific Temper and the Scientific Method in Science in India Through History, with Special Reference to Biology') have made some very significant observations in their papers. Highlighting the difficulties of the Indian scholars to be critical of our own scientific tradition, Chattopadhyaya points out how Alberuni, 'the most understanding visiting scientist to India before the modern period' (eleventh century AD), could both praise and criticize the astronomical, mathematical and philosophical ideas of the Indian scholars. Specially surprising appears to be the acceptance of the mythological explanation (in terms of *Rāhu*) of the solar eclipse and lunar eclipse by such eminent astronomers as Varāhamihira (sixth century AD) and Brahmagupta (seventh century AD). The 'surprise' is attributed by Alberuni to the fact that the Hindu astronomers including Varāhamihira, author of *Brhatsamhitā*, and Brahmagupta, author of *Brahmasiddhānta*, had perfectly known that the Moon

is eclipsed by the shadow of the Earth and the Sun is eclipsed by the Moon. How could they then defend their astronomical knowledge and professed mythological faith? Alberuni considers it 'a sort of [mythological] sin against [scientific] conscience'. Chattopadhyaya seems to share this view of Alberuni. Even to-day he observes 'the traditional Indian intellectual atmosphere' persists. While some of its elements are helpful for the cultivation of science, others hinder it. The main point emphasized by him is that it is not enough for the Indian scientist and the historian of science to be familiar with the classical texts; they must be self-critical, and have the intellectual courage to reject 'the dead way of the past'.

Unless and until we develop scientific temper, the objective study of history is sure to prove impossible. It is necessary also for general development of our country. But what is scientific temper? Bhargava and Chakrabarti defend it in terms of (i) scientific method and (ii) its application, (iii) recognition of scientific knowledge as the closest approximation to truth at a given time, (iv) rejection of what is incompatible with scientific knowledge and what is not indisputably establishable by scientific method, and (v) practically following the scientific method or approach in everyday life. Obviously this is a comprehensive and rigorous definition of scientific temper. Its last point is deeply shared and strongly defended by Chattopadhyaya. Scientific temper must not be confined to academia, library and laboratory. It must reach the life of the masses. Scientific temper should not be taken as a limited elitist affair.

The world of science, in a way, is democratic. In it everybody has the right to question. Science has no high priest who cannot be questioned. Scientific knowledge can never be claimed to be complete. It is always provisional. Scientific truths are said to be truths by consensus. The claim of a scientist about his own theory, though rests on evidence and tests, needs to be accepted by his peers working in the same field. This does not mean truth by social contract or any crass form of sociology of knowledge. Truth is not a product of contractual agreement. Rather, the so-called agreement or consensus is a result of the findings or tests and reasoning based thereupon.

The views of Bhargava and Chakrabarti on the nature of scientific progress and relation between science and supernatural are clear and persuasive. But their observation on the relation between science and religion may invite questioning. While it is true that the dogmatic religion hinders the growth of science, it is a historically established fact that many scholars, committed to some or other form of religion, have made a significant contribution to science, and further that many universities and institutions estab-

lished and patronized by religious authorities have promoted the growth of scientific knowledge. To ascertain the correct relation between science and religion one is required to have *both* a normative orientation and a historical perspective. The mixed character of science and non-science is clearly illustrated by the instructive history of biology and medicine in India. While 'our ancestors had rightly concluded that life, including all biological processes within us are dependent on the generation of heat' they have expressed many untenable opinions on the reproductive process both in animals and in plants. Referring to 'authoritative' works of Caraka, Suśruta and Parāśara, Bhargava and Chakrabarti show that while in some areas their findings and conclusions are amazingly correct, their views on many other matters are quite indefensible, at places extremely naive. For example, on the one hand, in *Garbhopaniṣad* we get 'a detailed and fascinating description of the day-to-day and monthly development of the human embryo . . . from conception to delivery' and, on the other hand, Suśruta's theory that the origin of life on our planet is due to 'the intervention of a superior agent' is clearly indefensible.

Vedic tradition left a mixed cultural heritage, partly rational and scientific and partly questionable or differently interpretable. To the post-vedic religious leaders and thinkers go the credit of raising fundamental questions about the reliability of the Vedic tradition. Instead of directly raising doubt about the Vedic authority the 'orthodox' thinkers of *diverse* persuasions used to offer different interpretations of one and the same text. For a long time this was the Indian hermeneutic tradition through which 'rational' thought developed in India. It is interesting to note that some of the followers of the Vedic tradition, notably Gandhi and Sri Aurobindo in the recent times, have paid high tribute to the founder-teachers of Buddhism and Jainism. It goes without saying that for the enrichment of scientific and philosophical cultures of India their contribution must be rated very high. They, like the Cārvākas, directly questioned the 'orthodox' systems. Criticism itself, one must remember, is an important input of cultural and epistemic growth.

In their attempt to answer the question why scientific method and temper did not develop in India in spite of its very old tradition of science, Bhargava and Chakrabarti offer some hypotheses which, like those of Udgaonkar and Narlikar, deserve careful consideration. Some may feel unhappy over the presupposition of this question that scientific method *did* not really develop in India. Does not this question rest upon a particular concept of scientific temper? Were our ancestors anti-science in their mental make up? Bhargava and Chakrabarti think that we have an in-built 'resistance to change' and this is not peculiar to the Indian society. All early

societies had this trait. The second reason for the lack of development of science in India is the hierarchical caste system giving rise to intellectually unhealthy gap between the literati and the laity. Finally, it seems the tradition of experimentation was lacking in our ancient and medieval culture.

The historian of science can hardly disregard the social and political circumstances within which he is obliged to work, grow or degenerate. Equally relevant to the career of science is its method. And for its communication or lack thereof the role of language in which it is expressed has also to be taken into account. Whether the scientist or the historian of science is a poet, or mystic or a religious person has certainly to do with the style and content of his language. But what is most important is the academic acceptability or otherwise of what he writes. The social implications of his view also contribute to the possible espousal or indifference to that view.

In his contribution ('A Perspective of Indian Science of 10th to 18th Centuries') Rahman, to start with, refers to the European approach to the history of science, highlighting the role of the medieval system of production controlled by feudal nobility and the church. The theoreticians working under the aegis of feudalism and later on of imperialism in Europe looked at the history of Asian development as an outgrowth of what was happening in Europe itself. The separate identity of the history of Asian science was not appreciated by them. This colonial attitude got accentuated in the nineteenth century due to the development of industrialization.

As mentioned before, Rahman, like Kosambi, thinks that the language of science in India, Sanskrit, in most cases, posed a sort of barrier between the writer and the reader. To this relative communicative inefficiency pointed reference was made earlier by Alberuni. Complex ideas expressed in compressed verses were not easily intelligible to the uninitiated scholar, not to speak of the ordinary people. As a result of this communicative difficulty most advanced ideas of science and philosophy remained available only to the Brahmanical literati, leaving the masses either in the darkness of ignorance or, at best, in the twilight of traditional wisdom. What is worse, excessive reliance on the oral tradition objectively encouraged a sense of timelessness or a history of the most authoritative form of knowledge. Given these social constraints, Alberuni critically observes, only those parts of theoretical sciences like Astrology, Astronomy and Physiology could develop here which had their such obvious practical uses as agricultural production, seasonal rituals and determining the time for royal military campaign. What Alberuni observes, especially on the socio-practical origin of science, is said to be true more or less of all societies. And his own emphasis on the theoretical aspect of the different branches of learning was perhaps mainly

due to his Ionian (not Greek in the narrow sense) logical and scientific orientation.

The increasing Islamic presence in India during the second millennium AD was followed up by the rising influence of scientific literature in Arabic and Persian. Because of the background of Aristotelian logic and Greek mathematics (in the extended sense) most of the writers of the important scientific treatises of the time tried to develop and use relatively simple and clear language which could be easily understood not only by the learned community but also by the layman. Among the famous scientific writers of the period one could refer to Haji Abdul Hamid (fourteenth century), Fatallah Farooqi of Akbar's time (1556–1605), Mohammad Faddil bin Alibin, Mohammad al Miskini al Ali Samarqandi of Humayun's time (1530–1556) Mulla Mahmud Jaunpuri (seventeenth century) and Amanullah Husaini during Jehangir's rule (1605–1627). Most of them wrote on various subjects like religion, mathematics, astronomy and geography. Farooqi's contribution to physiology and medicine is notable. Miskini's work was encyclopaedic in its scope. Husaini's work on agriculture is significant. Jaunpuri's writings on physics and cosmology, including space, time, number and astronomy proved influential. Another scholar who deserves special mention is Mirza Wulug Beg (1394–1449). He lived in Samarqand and headed the activity of the Samarqand astro-mathematical school of the sixteenth century. Raja Jaisingh (1686–1743), influenced by the Samarqand school, built observatories in Delhi, Jaipur, Mathura and Ujjain.

During the period under consideration the interaction between West Asia, Central Asia and India was many-sided and deep. Many scholarly books of Indian authors were translated in Persian and Arabic languages. It is during this period that initial attempts were being made to 'distance' scientific pursuits from the negative effects of religion. At the same time it has to be mentioned here that by and large the academia of the time continued to recognize the religious, agricultural and everyday needs as among the objects of right knowledge.

On the reasons why scientific development in India between tenth and eighteenth centuries was more or less sluggish the historians, as referred to before, are not unanimous. Some of them are of the view that it is because of the persistent division between science and technology. Secondly, as noted earlier, the familial-oral tradition, it seems, stood in the way of spreading the influence of science among the people at large. Thirdly, the rise of orthodoxy, both among some Muslims and some Hindus, proved a road-block on the way of scientific progress. Finally and interestingly enough, the liberal and the pluralists among the Hindus and the Muslims, the Sufis

and the devotees of the *bhakti* cults, for example, because of their primary emphasis on the emotional aspect of life, objectively downgraded the intellectual thrust necessary for the development of science. All these hypotheses deserve deeper analysis and closer examination.

Reflective approach to history does not recognize an artificially drawn division of labour between what is theoretical and what is practical. Even what seems to be purely practical from the standpoint of today or what is easily available in oral tradition and ordinary language, on examination, reveals its ideational or theoretical component. Human actions studied in history as event are in most cases traceable to some or other rational intention. Beliefs of historical agents are said to be due to certain *facts* which on scrutiny are found to be well-established theories. Survived theories of yesteryears are facts of today or fabrics of our present-day culture. These considerations are relevant, at least partly, to the understanding of the relation between science and technology, pure mathematics and applied mathematics, pure physics and applied physics, pure ethics and applied ethics. In search of 'pure' theories, some of us, particularly 'specialists', tend to complain that the thinkers of the ancient and the medieval times had been rather 'confused', inadvisedly mixing up some concepts of one discipline with other concepts of the neighbouring disciplines. For example, cosmology or higher theoretical physics of today, metaphysics and mathematics were indefensibly mixed up in the Indian and Ionian traditions. This criticism cuts either way. If we, the modern people, are justified in criticizing the ancient and medieval thinkers for mixing up different branches of learning, the latter can with equal justification accuse us of unnecessarily segregating naturally related subjects in the name of specialization. On this controversy Mohanty (in his paper 'Theory and Practice in Indian Philosophy') has something interesting to tell us.

From Hegel to Husserl many thinkers, more or less familiar with the works about Indian philosophy and Chinese philosophy, are of the view that the European philosophy, rooted in the Greek tradition, is claimed to be quite different from the other types of philosophy. The oriental philosophy, which comprised three 'stereotypes', the Chinese, Indian and Arabic systems of thinking, was, according to them, primarily practical, rather local in character, while in the Greeks do they find a truly universal life-interest of a purely theoretical attitude. By referring to Vātsyāyana's commentary on *Nyāyasūtras* and *Tattvacintāmaṇi* of Gaṅgeśa, Mohanty persuasively argues to clarify the point that the primacy of valid cognition has indeed been recognised by almost all Indian systems of thought. This can be brought out in different ways, for example, by analyzing the concepts of 'object', 'mean-

ing', and 'truth'. It can be illustrated also by showing the intertwined character of theory and practice, practicality of theory and theoreticity of practice. Another way of making the point clear is to spell out the relation between *dharma* and *mokṣa*, between individual practice and social praxis. In the Indian tradition *dharma* is not at all delinked from *karma*. *Dharmaśāstra* not only discusses the rituals but also their underlying ethical and juridical considerations.

'My claim', writes Mohanty, 'is that the nature of Indian philosophy is profoundly misunderstood if it is not recognized that much of it, at its best, was purely theoretical'. Also this claim is intimately related to the view that knowledge of truths, in Indian perception, is practically beneficial. For example, ethical knowledge is not only spiritually elevating but also practically, legally and administratively useful. Also one finds in *Carakasamhitā*, for example, besides knowledge of physiology, anatomy, surgery and pharmacology, extensive discourse on medical ethics and ecology.

It is not at all surprising that many Western scholars have misunderstood the culture of India down the centuries. After all they were foreigners. Given their ideas and values, it was indeed difficult for them to understand the distinction between the theoretical and the practical as we take it in India. The very theory-practice distinction, like the science-technology one, is being systematically misunderstood even by some of our own Indian scholars. When we speak of discovering India's scientific tradition or cultural heritage, and of shaping our future history in that 'light', some of us consciously or unconsciously betray our Western education and attitude.

The presence of West in India was not merely political and economic. With its cultural baggage was imported a mind set. Through English language and education it has got so deeply sunk in the psyche of at least a section of the literati that it is now proving extremely difficult to be free from its influence. Unfortunately, even the concepts and theories used by some of us, especially the modern and radical critics, are of Western origin. In a way we are intellectually and even emotionally alien in our own country. The point has been persuasively made, among others, by Mukhopadhyay (in his thoughtful paper, 'History of Science, and Two Metamorphoses of Minds').

We, the literati of India, exposed to Western theory of rationality, are often inclined to think that the science-related Western paradigm of development should be accepted by us. Otherwise, we are afraid, we are bound to be condemned as orthodox. Occasionally, though, we speak of Indian way of development, we are not at all clear about it. After the disintegration of the former USSR many of us have turned critical of it, preferring to remain silent about the decades of our 'friendship' with that country. About the

Chinese experiment with 'political socialism and economic capitalism' many of us are sceptical. But, when pressed for a positive answer of our own, we are not sure of our own say, if any.

However, one thing is perhaps clear and that is: in our vision of India of tomorrow the silently living and long surviving ethos of the people of this country does not figure in a prominent way. If we sincerely believe that India has an old religious tradition of it, is it not imperative on us to understand and explain its essence in clear terms? If we are really convinced that India has a long scientific tradition of its own, must we not try first to understand and explain its core concept of rationality? If we are honest in our profession about the richness of our cultural heritage, is it not our duty to analyze its basic components and present the same in intelligible idioms before the people?

A civilization is primarily shaped by how its past, ascertainable facts, ideas and values of the past, are 'emotionally and culturally appropriated' by the concerned people. The metamorphoses of Western mind is due to its *people's* commitment to a science-shaped way of life. This is not to suggest that they did not have many spiritual minds among them. The professional priests or scientists like Copernicus, Newton, Kant, Einstein, Eddington, Julian Huxley and Teilhard de Chardin were deeply spiritual. The metamorphosis of the Western mind, admittedly important in itself, will not be of much help for us in understanding our own history. What is primarily needed on our part is to try to get to our own roots. And for this purpose the West's way of understanding the East, or for that reason of India, is *likely* to hinder, not help, in discovering ourselves. We have to get back to the 'Swaraj in ideas' lost under the impact of British rule and education. When in our own light we understand the West, with a firm footing in our own identity we integrate our scientific and spiritual resources with the West's, we are mutually benefited. Not strained syncretism, but only genuine synthesis which is consistent with India's cultural personality, is the need of the hour.

All people of India, it is well known, are not followers of the Vedic tradition. Other traditions, due to other religious and philosophical outlooks, have also been at work in India. It is a fact that Buddhism and Islam have contributed much to the shaping of what is called Indian tradition to-day. The impact of the West, initially political and economic, has left behind a science-dominated and practice-oriented outlook among the educated Indians. Given the mixed composition of our culture, it is undeniable that most of us are deeply influenced by two different but not necessarily antagonistic sets of forces, one scientific and the other ethico-spiritual. Unless we take a narrow view of science or of philosophy, these two types of forces need not

make one's existence schizophrenic. Because of the dominant influence of science in Europe during the centuries after the Renaissance, even philosophy, which had earlier an autonomy of its own, has become more and more scientific. Most of the philosophers have allowed themselves to be 'underlabourer of science'. Mukhopadhyay reminds us that philosophers are increasingly becoming technicians, abandoning their age-old role of the sage. In the name of science a sort of scientism, a cult of worship of science, has been developing. While Mukhopadhyay is favourably disposed to science itself, he is obviously against what Hayek once called the counter-revolutionary role of science or abuse of reason. In the name of scientific culture one must not be uniformly critical of or indifferent to other forms of culture, humanistic or spiritual. Moreover, he favours a *liberal* concept of science. Why sense-based epistemology should not be regarded as scientific? Must our theories of knowledge be de-psychologized as demanded by some 'worshippers of science' in the West?

For obvious reasons we are referring, though sketchily, only to few aspects of our scientific and cultural heritage. There are so many other aspects of it with their very legitimate demand on our time and attention; when one thinks over the same, one feels struck by the richness of their *theoretical* foundations. For example, logic, language and their relevance to scientific discourse and communication are extremely important for our understanding of our history. From the contributions of Raja Ramanna ('Causality, Cardinality and Conditioned Reality') and S. Bhattacharyya ('Some Aspects of the Navya-Nyāya Theory of Language') we get an instructive idea, i.e. how 'old' ideas may be creatively used to grasp new problems of physics, syntax and semantics. Making use of the insights underlying the Buddhist theory of causation as functional dependence, *pratīya-samutpāda*, an aspect of instantaneous being, *kṣaṇika-vāda*, Raja Ramanna tries to show that a matrix can be formulated which, with the help of the Cantor diagonal method and the Cantor Continuum, would be able to accommodate the concepts of Classical and Relativistic Physics and Quantum Mechanics. Both the discrete and causal characters of reality are sought to be represented as unitary in terms of this view.

How does language succeed, if at all, in speaking about reality? How to interpret the relation between a sign and what is signified by it? What is the relation between natural language and artificial language? Which one of the two is primary? What are the roles and relative status of speech, language, gesture and posture for the purpose of meaning-conveyance? What is the difference and similarity between the different accounts (natural, conventional and divine) of word-object relationship? By raising these and

similar other questions and in the process of analyzing their answers from the standpoints of Nyāya, especially Navya-Nyāya, and Grammarians Bhattacharyya brings out the significance of different concepts of language. Also, in this connection, he interestingly refers to the views of some western thinkers.

Both for ascertaining and establishing relation between word and object, language is needed. Language also enables us to share our ideas and intentions with others. It has another role to perform, i.e. to make a fleeting experience more or less permanent. Language, as we know, may be formal and informal or ordinary. In both these forms of language there is logic. Not only philosophers and scientists but also common men make use of the rules of logic. Even the children have their own ways of reasoning. While few of us use logic consciously, most of us are under its influence unconsciously. Experience, reflection, and, particularly, education make the difference. It is in and through the spread of education that the unhealthy difference between the classes and the masses may be gradually removed, and the bad effects of ignorance minimized. Positively speaking, education helps one to realize what is best in him. However this is not to suggest that all persons should be educated uniformly. The ability and interest of the concerned ones, together with the social needs, have to be kept in view.

To understand the cultural heritage of India, its scientific and philosophical tradition, we are expected to know the educational systems, familial-oral and public, which were there in the ancient and medieval times. Also of interest to us are the ways how fine arts and crafts could be sustained and even at times developed. Some of these issues have been dealt with in the presentation ('Education in Ancient India (AD 300-1000): Some Aspects of Theory and Practice') of S. Sankaranarayanan.

Different religious orders had their different forms of education and, understandably, their contents were in accordance with the recognised goals of human life as laid down by the founders of those religions. Under different names, material, ethico-juridical and spiritual disciplines used to be taught. Grammar and philosophy were also given important place in their curricula. Needless to say, the Buddhist and the Jaina systems of education were in some important respects different from the Vedic system. But their similarity is remarkable and that explains, at least in part, how these systems were sustained by and addressed to the needs of a more or less unified cultural milieu. Religious difference did not destroy or interrupt their cultural interaction. The Indian science is not therefore to be taken either as Hindu science or Islamic science or the Buddhist science. It has been enriched by contributions by different groups and sects. Already we have noted the

Arabic and Persian influences on the different sciences of India. The different systems of thought in India had grown through mutual interaction. And that was possible partly because of the large interface of different types of social and academic interactions. Whenever this interaction came down to a low ebb, there was perceptible decline in our attainments.

It is well known that generalizations in history are unreliable. Even then we cannot avoid generalization altogether. After the advent of western education in India, there was not much of an interaction between the indigenous systems of education and the newly introduced British system. In response to the administrative needs of the rulers, it is true, a few institutions like Fort William Colloège, Sanskrit College (Benaras), Sanskrit College (Calcutta) and Calcutta Madrassas were set up. But at the ground level *Tols*, *Maktabas* and *Madrassas* fell into bad days; for these age-old institutions the patronage of the new government was either negligible or nil. The traditional patronage of the *zamindars* and *Nawabs* was fast decreasing or disappearing. Gradually they wore a deserted look and in many cases closed down. Pandits and Maulvis, notwithstanding their scholarship, did not receive the recognition necessary for the whole-hearted pursuit of classical learning. The reason was simple: they could not speak English language, the ruler's tongue. Even within the precincts of government institutions the difference—social, political and pay-wise—between the British and Indian teachers was glaring.

For their own requirement, prestige and administrative purpose the East India Company Government paid measured attention to introduce technical and medical education. In his contribution ('Advent of Western Medical Education in India') O.P. Jaggi tells us in detail the story of the introduction and rise of western medical education, allopathic system in particular. Concomitantly one witnesses the decline and fall of the indigenous systems of medical education and practice, *Āyurveda*, *Yunani* and *Siddha*. Historically speaking, the *Yunani* system was foreign in origin; but gradually it was indigenised during the medieval period. It is clear that the new patrons and practitioners of the western medical system did not much favour the idea of interaction with the prevailing Indian systems of the time.

Whatever period or whatever topic the historian writes on is *his* choice. This may sound trivially true. On reflection however the matter seems to be otherwise. There are some important points underlying the choice of the historian. This is so particularly when he is called upon to write on the history of a civilization or culture.

To start with, the point to be noted is that the historian is above all and after all a human being and as such he has his freedom in his theoretical

and practical activities as a historian. The element of choice that is often referred to in this connection is reflected in his selection and rejection of factual details. In other words, like any other social being, the historian, though objectively more or less determined, can always bring his own ideas and ideals to bear upon the subject he writes on.

The relevance and importance of historiography, *theoria* or vision of history, is specially felt by the historian of civilization. The obvious point, indicated above, that facts cannot totally dictate his approach has its two aspects, ontological and historiographical. Ontologically speaking, the historian is incurably free. In a way, one might say, as a human being he has no escape from his own freedom. He cannot totally disown it, even if he 'wants' to. Historiographically speaking, this freedom is felt by him when he stands before the boundless details of a civilization spread over millennia in time and intermixed with other civilizations in the neighbouring space. Some of these basic issues of civilizational historiography have been raised and discussed with creative insights by Daya Krishna in his presentation ('Prolegomena Towards Any Future Study of the History of Cultures and Civilizations').

The history of civilization may be likened to a human life. Both have many dimensions but one of them turns out to be dominant. Both human biography and civilizational historiography are situated and operative within a natural-causal nexus. But in view of the *essential* involvement of humans, including historians working within the concerned civilization, it assumes the dignity of a symbolic or meaningful life of its own which transcends the bounds of the said nexus. The historian, admittedly a biological being, is subject to the process of birth, growth, decay and death. But due to freedom as his ontological endowment he can perform many meaningful 'things', creates new situations and values and re-creates his social or collective past. This re-created past is known as history.

Engaged in re-creating or re-enacting the past the historians substantially rise above the sweep of linear time and partially succeed in removing the distance between the past and the present. The metaphors of linearity, sphericity and cyclicity need to be deciphered and understood. Most of us, including the historian and the common man, understand time in terms of space and space in terms of time. Space and time are interfused not only in architecture and sculpture but also in the historical rhythms of civilization. Spatially spread-out frontiers of civilization often extend beyond its geographical frontiers. For example, India as a civilization is not strictly delimited by seas and mountains. In the life of a civilization the rhythms of time

are often sought to be captured in terms of inexact, if not vain, periodization. One and the same segment of time past, present or future, may be alternatively constructed or visualized.

Daya Krishna is an ardent defender of alternative visions of Indian history. By implication he rejects the fancied view of unique and correct scientific history.

Actually speaking, attempts have been and are being already made to capture our history differently or alternatively—in archaeology, anthropology, the Purāṇas and the epics, the *Rāmāyaṇa* and the *Mahābhārata*, often referred to as *upavedas*. Literary vision of history may not be seriously taken by the working historians. But that they are not lightly dismissed either is evident from the fact that these are often consulted by historians as source materials.

Every distinguished historian or theoretician of history, Gibbon, Hegel or Marx, is said to have his own vision of history. For example, Hegel tries to show how the Spirit realizes itself step by step in the Orient—China and India—the Arabic world and Europe in general and Germany in particular. Marx's view of human history discloses how the injustice of class society due to exploitation of the poor by the rich is being gradually eliminated through class-struggle. Tagore and Hobhouse see history as marked by increasing human cooperation and harmony. Croce echoes Hegel when he says that history is the story of liberty. Toynbee's study of history is informed of the crucifixion of Christ. There are so many other visions of history, of the 'same' history, local, national or civilizational, and global.

Abstract in look, history is claimed to be a mode of concrete value-realization. The historian is not only a knower but also a doer. He embodies in him both *Śāstric* knowledge and *śilpa* or skill of meaningful delineation and interpretation. He is engaged in the pursuit of what may be called a *puruṣārtha*. In the process he is being both influenced by and struggling with his own culturally inherited *saṁskāras*. Born in a particular cultural milieu every historian has his native *saṁskāras*. Euro-centricity or Indo-centricity, although justifiably used in a pejorative sense, may be used, given due qualification and clarification, also as expressive of a cultural temper.

What happens in the life of a historian in terms of what he expresses and what he represses has its parallels also in the life of a civilization. The ingoings of individual life and those of cultural life, though not causally related, are mutually interactive in character. 'Return of the repressed' and 'civilizational amnesia' are evident in different ways in both areas. A civilization is not happy with its past guilts and failures, fancied or otherwise. Nor the historian is intellectually or emotionally fordable with his traditional

sense of guilt and failure, founded or otherwise. By creating or in the process of creation of new values he tries to overcome the same.

Whatever might be the available facts, the historian's freedom to interpret and re-interpret the 'same' in the light of his vision and values remains always open-ended. In this creative work he is aided not only by his *śāstra*, knowledge and *śilpa*, skill, but also by his imagination or *kalpanā*. *Kalpanā* is that competence which enables us to view and review the same facts differently and alternatively (*vikalpas*). This explains, at least in part, how different historians living as they do within the same culture and in the same age visualize their past differently—conservatively, liberally and radically. While one favours the preservation of the sacred past, the other defends the idea of modifying it in the pursuit of new values. The radical historian goes further ahead and assumes the practical role of a reformer or social activist. He views the otherwise 'plain' process of social transition as a series of committed confrontation or struggle.

In the historian's creative-interpretative process his desires and dreams, *smṛtis*, get silently but effectively involved. In a way the historian of civilization is a half-conscious builder of it. He builds it and lives in it not only for himself but also tries to make others share it with him. This is self's world intended to be shared and populated by others. That is why, in a way, within the same cultural space we live in different worlds carved out by different historians and other visualizers of the past.

Historical past, as stated earlier, is not only contemporaneous but also futuristic in its value-seeking and goal-seeking orientation. 'The story of a civilization' is said to be 'simultaneously a story of its expansion in space and its development over time'. This development is marked by change and modifications, encounter with other cultures and civilizations and its own inner development propelled by its own chosen values and potentiality to realize the same. The civilization of India seems to be infused with its own 'primordial vision' as expressed in its own concepts, images and symbols. This liberal vision of historiography is essentially pluralist in orientation and optimist in tenor.

Some of the features of the Project (PHISPC) to which this volume is intended to be an introduction perhaps deserve specific mention. Directly or indirectly these have already been mentioned in brief. The basic terms of the discourse of this Project are obviously of Indian origin and addressed to the people of India. But even at the initial stage of this discourse, not to speak of its subsequent development, one would see clearly its trans-national and non-chauvinistic orientation.

Secondly, the contributions under consideration, apart from being

interdisciplinary in character, are informed of a comprehensive and unitary goal. This goal is not being sought to be realized by a single methodological regime. The freedom of the individual authors is not to be compromised by an *a priori* and externally dictated letter of intent. It is mainly through in-depth discourse and intensive interaction that a sort of consensus, one hopes, would emerge.

Thirdly, since the scholars involved in the Project are not obviously working under the aspect of eternity their way of being objective is bound to have something to do with the spirit of modern time (*yugadharma*), of modernity itself, to be more specific. It cannot be alien to the spirit of tradition or *svadharma* of India. The spirit of modernity, broadly speaking, may be defined in terms of social production, political representation, cultural creation and spiritual reflection. In the light of this liberal definition, the artificially drawn division between the past, the present and the future tend to collapse. They interpenetrate. For our cultural creativity and social productivity we not only appropriate our past but also are obliged to contribute to the future.

Fourthly, the received wisdom of India has social praxis in it as one of its basic characteristics. We all, producers and consumers of history, are duty-bound to the needs of social reconstruction and cultural transformation. In the process of handing down to our successors what we have received from our predecessors we are expected to enrich it, materially as well as spiritually, to the best possible extent. For the purpose the writers of our time, especially theory-oriented historians, would be well advised to reject an increasingly fragmented view of social reality, an unintended fallout of practical and intellectual division of labour. Positively speaking, they are expected to highlight the organic linkages obtained between different constituents of culture. In their own ways they can also substantially contribute to the process of strengthening the modern social and political institutions. Finally, their 'moral vision (or plurality of such visions)' may significantly 'shape(s) the popular psyche'.

Compared to an orderly execution of the Project, its conceptual visualization seems to be easy. In practice its shape will be determined by how it is received and criticized by its intended audience, both learned and lay. Communicated comments, responses and criticism will be accepted as contribution.

On the Nature of Interconnection between Science, Technology, Philosophy and Culture

D. P. CHATTOPADHYAYA

I

The nature of interconnection between science, technology, philosophy and culture may be, in fact has been, analysed and understood in very many ways. First, it will be shown from the commonsense or pre-theoretical point of view that every person combines in his world-view the basic aspects of his life, scientific, technological, geographical, historical, and economic. Secondly, I will indicate how at the theoretical plane one tries to re-do the same thing in a more systematic and refined way. Thirdly, our attention may be focussed on the distinction as well as the relation between civilization and culture, between the material and the spiritual aspects of human life. Fourthly, I will try to explain the importance of the man-environment relationship. In the process it will be apparent that even the higher forms of culture cannot be completely free from the environmental conditions. Fifthly, I will argue that even the abstract disciplines like mathematics are influenced by practical and social considerations. In this connection, the relation between natural sciences, humanities, and mathematics will be briefly indicated. Sixthly, comments will be offered to show the existence of a close relation between environment, human nature, medicine, ethics, language, technology, and philosophy. Finally, I will argue to establish the point that philosophy, science, technology, and culture are, in fact, an interwoven fabric of human civilization and that their speciation, differentiation of compartmentalization is mainly due to theoretical needs for specialization. Rightly understood, even these theoretical needs have their unmistakable practical underpinnings.

All branches of knowledge, rightly viewed, are complementary quests for and enlargement of human freedom.¹

First, we may view the issue from a very *commonsense standpoint*. In our daily life, in our pre-theoretical and pre-reflective moments, we all are scientists in a sense, make use of technology, are accultured in one way or the other, and stand committed to some or the other world-view or philosophy. It becomes clear, on reflection, that everyone is his or her historian. Endowed as we are with memory, we cannot but recollect what has happened to us as well as to the people around us over a period of time. Psychologically speaking, human memory is classificatory and organised. Even our memory-failure or inability to recollect something of the past has its place within our memory. In brief, history is an integral part of humanity, i.e., native to the human nature itself.

Similarly, it may be pointed out that we are our own economists, geographers, technologists, and so on. If economics is construed as the study of the relationship between human acts and the limited resources available for the purpose of realizing the same we are all engaged, consciously or unconsciously, in some or the other economic pursuit. Human existence without aims is nearly impossible. Equally impossible is to conceive human life which, relative to its aims, knows no resource-constraint. Therefore, humans are destined to be economic.

We cannot live and successfully move in the world or any part of it without defining, articulately or inarticulately, our relationship with our environment, immediate or not so immediate. Our body-mind complex, open to information inflow, is always more or less environmentally informed.²

Technology is not something very alien. That we know what fire is and put it to different uses is an evidence of our being wedded to what may be called fire technology. That we put clothes on our body, live in a house, try to protect our body from the bad effects of heat and cold, that we cook our foods, rather than taking raw, are among the direct evidences of the indispensability of technology to our life and living.

Just a little intellectual probing makes it clear that the uses of technology are based on our scientific understanding. Without understanding the laws or principles of science, growth of technology and its forms are not at all possible. Our experience of the world around us, of our own selves as well as of other selves exhibits some patterns. These empirical patterns or generalizations constitute the sub-structure of science. Given refinement and reflection, we construct, on the basis of science, some higher-level principles purported to explain somewhat, in an abstract manner, the pheno-

mena and the processes studied in specialized sciences. These higher-level principles are not necessarily addressed to natural phenomena.

Also of concern to us are the rules and regulations which ensure civilized life, peaceful polity and orderly development. Often these principles are known as laws and religious injunctions, prohibitive and prescriptive. All that we do and need are not necessarily practical or instrumental. We have in us many impulses which, superficially speaking, are useless. Love for beautiful things, liking for musical sounds, will to improve the quality of our motivation and action are among the innumerable cultural traits of human nature. If civilization is basically concerned with the material aspect of our life, culture primarily consists of the qualities of our very being, freedom and different forms of its articulation.³ Civilization has been likened to a golden ring and culture to its shine. In other words, culture need not always be imparted from without. Like history, culture is native to human nature.

II

The second important way of understanding life, science, technology, philosophy and culture may be called *theoretical*. One and the same domain of phenomena may be theorised in different ways. For example, history may be narrativistic, i.e., like story, theory-loaded or ideological, typological, local, regional, and even universal. Both level-wise and scope-wise history may be of different types. Even at its narrativistic base-line, history is not free from minimal theoretical underpinnings. The point may be clarified by highlighting the distinction between chronicle and history. The text of history is not like a thing-in-itself. It always bears the imprints of human interpretation and its cultural context. As we draw advisable distinction between micro-economics and macro-economics, a similar distinction is evident between (a) history of micro events like individual action specific in respect of its space-time address, and (b) macro events and processes spread over a period of time and an area of geography.

Further, the historians of positivist persuasion are in favour of describing their subject-matter as objectively or faithfully as possible. They try to keep history as a value-free discipline. In contrast, theory-intoxicated and ideologically motivated historians find no 'hard' facts in history. All facts, to their mind, are open to alternative, not necessarily antagonistic, formulations. For example, history may be viewed as an account of class-struggle or of racial strife. Also history has been written in terms of conflicts between different nations and imperial powers.

When we come to the question of writing history of science and culture, the narrativistic account and the micro-approach prove hopelessly inadequate. Instead we are obliged to follow typological and macro methods.

The diversity of approaches is also evident in the fields of economics, economic history, technology and technological history. One very influential approach, basically economic in character, is formulated in terms of the prevailing mode of production, pastoral, agrarian or industrial. Implicit in this approach is the role of technology of the concerned mode of production. This approach is generally attributed to Marx, Engels and their followers, though its distinct elements were already discernible in the writings of pre-Marxist anthropologists such as L.H. Morgan.

Another school of opinion is in favour of interpreting the history of technology in a secular manner, keeping the economic factors more or less out of its ambit. In many models of technological history economic factors are assumed to be exogenous and as such substantially ignored.

An opposite tendency is also there in the field of economic history. Several models of economic history have been built in terms of some macro variables like income, saving, investment and employment. The absence of technology as an input or variable is conspicuous. This approach may be called purely economic.

Our own perception is that neither the economic factors nor the technological ones operate in a mutually exclusive manner. They interact and interpenetrate. Their interface is unmistakable.

But more important in this context is to note how these two sets of factors are closely related to their cultural background. The pure economic theory of history or the pure technological theory of history is an ideal-typical accentuation of relevant factors, consciously disregarding other factors only for the limited heuristic purpose.

This only highlights the possibility of alternative conceptions or formulations of history. These alternatives are not always antagonistic. Positively speaking, the plausibility of these alternative approaches does not clash at all with one's programme of writing comprehensive history of a civilization covering economic, scientific, technological and cultural events and processes. Perhaps the time has come when the need for an integral or system-theoretic approach is being increasingly felt to neutralise the ill-effects of excessive compartmentalization of human knowledge. Like the life of an individual itself, the life of a civilization is in a way organically textured. For the analytic purpose, its vertical and horizontal threads, warp and woof, may be discerned and described. But more instructive appears to be its holistic or textured presentation.⁴

Perhaps a word of caution is called for here. In the name of integration, system-theoretic approach, or holism, one must not lose sight of the specifics of the different areas of life, individual and collective, theoretical and practical. Disregard of this caution often lands us in metaphysical generalizations not relatable to the factual findings. Both the ends of theoretical enterprise, general principles and specific details, deserve careful attention, rational integration, and critical scrutiny.

III

Our third point, to start with, is concerned with the *relation between civilization and culture*. At the pre-reflective level these two terms are often used in an interchangeable manner as if there is no important distinction between them. Moreover, these two terms are fairly general and, understandably, do not take due note of the distinction between different branches of knowledge.

For the purpose of refined understanding and analysis it is advisable to try to follow the distinction between the meaning of *civilization* and *culture*. The commonsense meaning of *civilization* highlights the difference between the *barbaric* state of society and the state of established *civil* society. Also it draws our attention to the *pre-social* stage of human living and the *social* one. One gets the impression that without some institutional form of joint living the conceptual transition from the *pre-social* to the *social*, from the *barbaric* to the *civil* state of society cannot be made intelligible. This transition is said to be *conceptual*, rather than *historical*, because of the non-availability of historical data in support of the view. But it is easily conceivable that the living and survival of the humans are contingent upon some normative dispositions and law-governed conduct.

Judged by these criteria, even the barbaric society may claim to have elements of civil society or even civilization within it. It is to be remembered in this connection that the Hellenic peoples used to describe all non-Hellenic peoples, especially the ancient northern European ones, as barbaric. A pejorative sense was attached to the word *barbarism*. In a descriptive sense it denoted the non-Hellenic peoples. Somewhat similarly, the peoples of Indus Valley and the Indo-Gangetic Valley used to refer to the Ionian or Greek peoples as (phonetically) *Yavanas*. Later on, even the peoples of non-Ionian origin like those who came from Arab, Central Asia and the trans-Caucasian areas were came to be known as *Yavana*. Even here to the word *Yavana* a pejorative sense was attached. One need not attribute much importance to self-laudatory and other-critical ethno-centrism, because their factual contents are often found to be very thin.⁵

Both etymologically and semantically, *culture* is the result of some sort of tillage or cultivation. It is in terms of the acts of cultivation that *culture* is distinguishable from what is *natural*. Also it may be looked at otherwise. Culture is rooted in some or other *cult*, the suffix *ure* stands for the *result* or *function* of some action and process as evident from such words as *scripture*, *enclosure*, and *composure*.

Still different ways of understanding the distinction between *civilization* and *culture* are available. For example, metaphorically speaking, civilization has been likened to a ring of gold and culture to its shine. The former seems to be more material and the latter is less so or spiritual. Secondly, in a philosophic vein it has been said that civilization is what we do *possess* or have and culture is what we *are*. The former primarily stands for such means of living, individual and community, as houses, roads, ponds, tools, utensils and dresses, while the latter primarily denotes the finer things of life such as altruistic disposition, moral compassion, aesthetic feelings and what flow out of them. In brief, one might say, whereas civilization is basically concerned with the material aspects of life, culture with the spiritual ones. But closer scrutiny reveals that even this line of distinction is not hard and fast; it keeps on changing and is 'a matter of more or less', not exactly ascertainable. Where or at what level the materiality of civilization ends and the spirituality of culture begins can hardly be indicated in a clear way.

Though provisional and conceptual, the distinction between civilization and culture helps us to define better the relationship between science, philosophy, technology and culture.

In a general way it may be said that each one of these forms of culture is peculiarly human. What is peculiar to human being? Certainly it is not body. Many non-human creatures have their bodies environmentally formed and at least some of those bodies are proto-human bodies. Broadly speaking, there are two ways of having information. First, information may be a natural inflow into a living organism, and secondly, information may be augmented, expanded and transformed by some internal powers like end-consciousness, means-consciousness, and intelligence to conjoin the two. The second form of information gathering or information expansion is peculiar to human beings.

In what is this peculiar human ability or cognitive capacity rooted? Many hypotheses on the matter have been offered. Experience, consciousness, reason, ratiocinative capacity, sign-using capacity and tool-using capacity are among the key terms around which different hypotheses have been framed. It may be shown that these different capacities have a generic unity of their own.

The basic point may be explicated in terms of the fundamental notion of *freedom*. Humans are free in a sense unknown to other creatures including the bipeds. First, human experience is exceptional because of its highly categorised or organised nature. We have five external organs. Besides, if we have to believe the Indian psychologists, we are endowed with an additional internal sense called mind, *manas*. To the last is ascribed the coordinative competence of the sense-information gathered in and through the five different external sense-organs. Further, human memory is longer and subtler than that of other non-human creatures. It enables us to endlessly expand the horizons of our environment or world.

IV

Situated in an environment and shaped by a particular civilization, humans are free to scale the higher reaches of culture. Being embodied as we are, we do belong to a particular territory. Physical geography is indeed very important to our life. As the proverbial fish cannot live out of water, the human cannot live for long out of land either. Even the migratory birds return to their original habitat. It is human freedom which can partly undo the effects of migration. Even in the case of human, the migrants psychologically long for the land to which they originally belonged and almost universally carry in them a nostalgic and lingering memory of it. It is hard to erase race memory. Even the nomadic tribes which left India long ago, and now roam about in Europe can well recall their Indic myths and words.

In the man-environment relationship two things deserve special mention, (a) effects of geography on human nature, and (b) the human capacities which are more or less free from the effects of geography or environment.

For example, our food habits and the types of clothes we use largely depend on the climatic conditions within which we live. The Eskimos cannot expect to have the sort of food to which we, the tropical peoples, are used to. The converse is also obviously true. The geographical difference between the peoples of the temperate zone and those of the tropical zone is also considerable. Forest, water and mineral resources make a lot of differences to our modes of living. Mere notional availability of resources is not enough. Their actual usability is of prime importance. For instance, river waters of the extreme cold areas which remain frozen for the most part of the year cannot be that useful as those in the countries with warm climate.⁶

Climatic conditions make a lot of difference to the forms of life of the

people concerned. Even if other living conditions are the same, peoples of the temperate zone are found to be more hardworking than their brethren who live in the tropical conditions. Those who live in highly warm conditions get easily tired and exhausted. However, this point needs qualification. The effects of climatic conditions on human life can be considerably neutralised by the use of appropriate technology. If we do not clearly bear in our minds the importance of this point, we are likely to commit the fallacy of Montesquieu and others who maintain that civilization and even culture are almost a direct function of climatic or geographical conditions. This fallacious view has even been pressed to the absurd extent that outside the temperate zone civilization and culture of high order cannot develop at all. This absurd approach partly accounts for Eurocentrism and the rise of racialism. The emergence of developed civilizations and the records we have of them expose the hollowness of this view.

Moreover, it fails to take note of the neutralising effects of technology on the civilized life. By using different types of clothes we can protect our bodies from the harmful effects of climate. Besides, the technology of making dwelling houses cool in warm weather and warm in cold weather have been known to the people since the pre-historical past. Knowledge of different types of fuels and their uses, knowledge of building different forms of house, and of different materials used for the purpose, and knowledge of choosing suitable sites for construction of villages and towns are among the basic technological determinants of human habitation and living.

Other than the modern technology of air-conditioning, various forms of heating and cooling were known to the people of antiquity and of the medieval age. Even today, relatively poor Eskimos of the arctic zone have their own ways of making warm shoes and dresses, of building dwelling units and constructing canoes to go into the deep sea for fishing and killing whales. Comparable technologies are also available in our own country. Those who live in the cold conditions of the high reaches of the Himalayas make use of their indigenous technology for survival. Needless to add, their food habits and dresses are quite different from ours.⁷

To take another example, modes of transport are also bound to be different because of different geographical conditions. Boats for inland water transport are quite different from those used by the fishermen operating in estuary or coastal areas. Still different is the type of wooden boats. *Dhous*, for example, used for deep-sea crossing. Convincing evidences are available that both in the east and the west coasts of India there were a number of ports and shipyards. The technique of building deep sea-going boats and that of navigating them properly are still available in India.

V

Not only our ways of living, but also our modes of thinking, forms of feeling, and their articulations are, to some extent, moulded by our geographical conditions.

From the cave paintings of the ancient or pre-historic people we get an idea of where they lived, of the sort of tools they used to kill their prey and also of the kind of animals they ate. From the inscriptions of different periods we come to know of various expeditions undertaken by the kings and their aims. Some inscriptions give us a clear idea of the sorts of transport used on land and sea in such expeditions. In a way, archaeology and numismatology are not only a very important part of history but also a gateway to epistemology. Even the ideas of the abstract forms of knowledge like cosmology, theology and praxiology are available from the relics of the past. For example, from Ashoka's inscriptions we gather not only of his Kalinga expedition but also of his conversion to the Buddhist philosophy of peace and non-violence.

From the architectural styles of temples, *stūpas* and *vihāras* one can form a clear idea of the builders' geometrical knowledge. The significance of the use of circles, squares, rectangles and triangles, is by itself an area of interesting study. Incidentally, this also indicates the concrete relation between abstract disciplines like arithmetic and geometry, on the one hand, and architecture and town planning, on the other.⁸

It is well known that Vedic mathematics, especially geometry, had a very important relation with the construction of different forms of altar (*vedi*). Comparable was the relation between the Egyptian (Greek) geometers and the technique of measuring correctly plots of land on either banks of the Nile after the previous land-demarcation marks used to be washed away by floods. Systematic method of counting and measuring is an inseparable part of civil life. The Babylonians are said to have developed a sexagesimal system of expressing numbers in cuneiform writing. The Egyptians, credited to have developed a system of numeration, using hieroglyphic, hieratic and demotic notations, apparently experienced, like the Babylonians before them, a lot of difficulty in dealing with fractions. To the Indians is attributed the credit for the introduction of the decimal place-value system, a modern form of numerals with the symbol of zero. Some of the Sanskrit synonyms of 0[zero] are *śūnya*, *vyoma*, *ākāśa* and *pūrṇa*. Zero is accorded the supreme ontological status by the Buddhists of the *Śūnyavādi* persuasion. Zero had two types of use, word-numeral and symbolic. This accounts for the development of simplified methods of fundamental opera-

tions and for the calculation by the rule of three. These Indian innovations appear to have been accepted by the Arabic scholars under the patronage of the Abbasid Khalifs at Baghdad towards the end of the first millennium AD.

Not only the abstract mathematical disciplines but also the science of first principles, cosmology, had a lot to do with the human encounter of such forces or elements of nature as, earth, water, fire or energy (or sun as its source) and air. Not only in ancient India but also in Greece and China we come across references to one or several of these principles responsible for all that is there in the universe.

Perhaps the more interesting part of cosmology is not the recognition of the variety of beings and things but their unity of Being. While the ancient cosmologist was empirically obliged to recognise the individuated variety of objects, he was equally interested to discover a Cosmic principle like *Rta* or Universal law underlying all that exists and moves. The contemplation of the relation between 'multiverse' and Universe, 'chaos' and Cosmos, was distinctly metaphysical and speculative in character. At the same time, it is to be noted that the speculation was inspired by the experience of variety, on the one hand, and the search for unitarian principle(s), on the other.

It is no wonder that a *Rta*-like principle is also found in the western thought. Often it has been referred to as the principle of Harmony. Harmony is all-pervading—natural, social and even cosmic. Some forms of harmony are perceptible and some forms are understandable. Still some other forms are there which are hidden and scientists are obliged to postulate them. Without this sort of postulations, the search for law-governed orderliness in music, mathematics, physics and metaphysics makes no sense.

The very possibility of understanding the laws of nature and society presupposes their existence in the form of harmonic structures. The precision in measurement of the different areas of the physical universe, terrestrial or celestial, cosmic or atomic, is not arbitrary. Some or other forms of orderliness is objectively grounded in nature. Otherwise, we are forced to fall back on a contrary and untenable assumption, viz., all scientific orderliness is man-made, an imposition or dictation of the human mind. Had all the objects of nature been equally amenable only to one particular form of accurate measurement, human mind could be spared of the trouble of innovating different types of number and different branches of arithmetic, algebra and geometry. Positively speaking, what forms of language, mathematical or literary, we are required to use, largely depends on the characteristics of the objects concerned. Different domains deserve different forms of treatment, theorization, systematization and, if possible,

axiomatisation. Not only for cosmological theories but also for accurate expression of atomic theories, mathematics was found to be necessary. The concepts like *aṇu* and *paramāṇu* and their combinations could not possibly be handled without the notion of the infinitesimal. It has been claimed that the idea of infinitesimal was used not only in the context of material atoms but also with references to the nature of the *Brahman* and that of *Self* (*Ātman*). *Brahman* has been described as smaller than the small and the *Self* as small (*aṇu*).

In India the concept of infinitesimal calculus has also been used by the astronomers for expressing the instantaneous motion of a planet, the 'position-angle' of the ecliptic with any secondary to the equator, the surface and volume of a sphere and the value of $\sqrt{2}$, $\sqrt{3}$ or π (π).

It has been rightly observed that the dual concepts of infinitesimals and infinities have raised foundational problems in the History of Mathematics. From the discovery of irrational numbers or incommensurable magnitudes (both in India and Greece) to the contemporary debate between intuitionists like Krönecker, Brouwer and their followers, on the one hand, and formalists like Cantor, Hilbert and their followers, on the other, it is no wonder that the history of infinitesimals with particular reference to its philosophical implications is being seriously studied. It is generally agreed upon that infinities and infinitesimals are not merely of heuristic significance and that they do have their ontological warrant. Their use enables us to grasp the complexity of natural phenomena, not otherwise available to purely empirical investigations.⁹

History of Mathematics may be studied both as an *autonomous* discipline, ignoring its interaction with non-mathematical disciplines and as an *integral* part of other branches of knowledge, natural and social. Perhaps the researchers of any inter-disciplinary programme will be well advised to follow the second approach. Mathematics is not an alien subject. It is very much a part of our daily life as well as an intellectual pursuit. In this connection I would like to quote two passages from the writings of two very eminent mathematicians.

Most people, mathematicians and others will agree that mathematics is not an empirical science, or at least that it is practiced in a manner which differs in several decisive respects from the techniques of the empirical sciences. And, yet its development is very closely linked with the natural sciences. One of its main branches, geometry, actually started as a natural, empirical science. Some of the best inspirations of modern mathematics (I believe, the best ones) clearly originated in the natural sciences. The methods of mathematics pervade and dominate the 'theoretical' divisions of the natural sciences. In modern empirical sciences it has become

more and more a major criterion of success whether they have become accessible to the mathematical method or to the near-mathematical methods of physics. Indeed, throughout the natural sciences an unbroken chain of successive pseudomorphoses, all of them pressing toward mathematics, and almost identified with the idea of scientific progress, has become more and more evident. Biology becomes increasingly pervaded by chemistry and physics, chemistry by experimental and theoretical physics, and physics by very mathematical forms of theoretical physics.—John von Neumann, 'The Mathematician', 1945.

Von Neumann's own works in the wide areas of quantum mechanics, probability, self-reproductive machines and (game-theoretic) economics convincingly show the interfaces of seemingly unrelatable disciplines.

The same may be said of the works of Wiener:

While the historical facts in any concrete situation rarely point a clear-cut moral, it is worthwhile noting that the recent *fertility of harmonic analysis* has followed a refertilization of the field with physical ideas. It is a falsification of the history of mathematics to represent pure mathematics as a self-contained science drawing inspiration from itself along and morally taking in its own washing. Even the most abstract ideas of the present time have something of a physical history. It is quite a tenable point of view to urge this even in such field as that of the calculus of assemblages, whose exponents, Cantor and Zermelo, have been deeply interested in problems of statistical mechanics. Not even the influence of this theory on the theory of integration, and indirectly on the theory of Fourier series, is entirely foreign to physics. The somewhat snobbish point of view of the purely abstract mathematician would draw but little support from mathematical history. On the other hand, whenever applied mathematics has been merely a technical employment of methods already traditional and jejune, it has been very poor applied mathematics. The desideratum in mathematical as well as physical work is an attitude which is not indifferent to the extremely instructive nature of actual physical situations, yet which is not dominated by these to the dwarfing and paralyzing of its intellectual originality. Viewed as a whole, the theory of harmonic analysis has a very fine record of this sort. It is not a young theory, but neither is it yet in its dotage. There is much more to be learned and much more to be proved.—Norbert Wiener, *The Historical Background of Harmonic Analysis*, 1938.

From the above two quotations we get a fairly clear idea how mathematics is related to other disciplines, scientific and humanistic.

VI

Medical science is another very instructive area which shows a close interconnection between physical nature, human nature or psychology, biology, biochemistry and technology in the form of surgery. If one goes carefully

through *Caraka-Saṁhitā*, it becomes clear that medical science has also a thick moral content in it. Medicine and ethics are inseparable. The ethos of the physician, of the nurse, of the cooperative patient and the drugs of good quality are the four main ingredients for proper treatment and cure of disease. Disease itself is an expression of imbalance between human nature and its attending environmental conditions like heat, cold, availability or otherwise of potable water, nutritious food, etc. Besides this 'external' balance between man and nature, another or internal sort of imbalance is also referred to as the possible cause of disease. If the delicate balance between *śleṣma* (cough), *pitta* (pancreatic juice) and *vāyu* (air) is disturbed, the body is visited by some or other disease. Therefore, freedom from illness is contingent upon two types of balance, internal and external. The method of diagnosis recommended in the *Caraka-Saṁhitā* highlights the importance of the relationship between environment and organism and also how to keep the latter fit in terms of food, drink and drug when it falls sick.

To understand Āyurveda of Indian tradition one must be familiar with three important treatises (*Vṛhattraṇī*), namely, *Caraka-Saṁhitā*, *Suśruta-Saṁhitā*, and *Aṣṭāṅga-Saṁgraha*. If one goes through these works one cannot but be struck by the authors' knowledge of anatomy, physiology, pharmacology, climatology, botany, zoology, physics, chemistry, mineralogy and also philosophy. It is interesting to note that different schools of Indian philosophy like *Nyāya*, *Vaiśeṣika* and Buddhism have their own different approaches to the medical science. This shows, among other things, that even a science like medicine which is thick in empirical content, lends itself to different ways of philosophical theorization.¹⁰

The medical science, as conceived in India, is not merely a matter of therapeutic technique; it also has a deep humanistic aspect. When one enumerates the essential qualifications of the physician, of drugs, of the nurse and those of the patient, the point becomes clear. It is not enough that the physician knows his theoretical discipline; he is expected to be much experienced, practically skillful and clean in his body and dresses. Secondly, inefficacious or substandard drug is ethically prohibited. Thirdly, the nurse, like the physician, must also be clean and, what is more noteworthy, she is expected to be emotionally attached to the patient. Finally, the patient himself must have the moral courage to express frankly the symptoms of his disease and he should be disciplined enough to follow the physician's and the nurse's instructions.

Philosophical underpinnings of the medical science also deserve careful attention. Philosophical concepts like *karma*, causality, reasoning or debate have been accorded very important place in medicine. Scientific

debate between the proponents of different philosophical concepts is always welcome in the Indian tradition of medicine.

Apart from medicine and environment, philosophy brings out another important aspect of human biology. Earlier it has been said that human organism is more informed by its environment than any other organism. But philosophical analysis brings to the fore some native competences, primarily freedom and symbolising capacity. Unlike the environment-induced competences, these are more or less 'innate' or autonomous. I say 'more or less' because externally given capacities and the internally initiated ones are mutually supportive and cannot be completely separated. For example, full import of external stimuli, natural or cultural, can hardly be grasped by an organism unless its receptive and interpretative capacity are of a fairly high order. From the other end it may be pointed out that internal capacities cannot be satisfactorily developed without the support of appropriate external inputs, stimuli or information. The point may easily be illustrated by referring to the impaired linguistic capacity of some persons who are biologically handicapped. For example, dumb and deaf persons cannot speak but they do have deep sensitivity, developed linguistic and intellectual abilities. The classical case of Helen Keller makes it quite clear how on the basis of meagre external input massive internal, i.e., cultural and intellectual, output is possible. In recent times, the life and works of Stephen Hawking illustrate the same point. Unable to write, or even to speak clearly, Hawking, Professor of Mathematics at Cambridge University, is widely regarded as one of the most brilliant theoretical physicist, since Einstein. It is universally known that the persons with impaired sense organs are found to have extraordinary internal sensitivity and capacity. The underlying psychobiological points have been clearly brought out by some linguists and biolinguists like Chomsky and Lenneberg. The basic points to be remembered in this context are two-fold. First, in the biology of language we may disregard, to start with, the problems of speech and motor production and focus our attention on the understanding of language as a special form of pattern recognition. The advisability of this approach is proved by the recent efforts made to build a machine that can answer questions fed into it in the form of unedited English. Secondly, in a way all organisms, in general, and the human ones in particular, are self-organising system. This suggests that human organisms are more or less, but *not* boundlessly, free for the purpose of specific organization of language processing and articulating. In brief, our biological matrix, endowed with specifiable characters determining the outcome of what is given to the concerned organism, can yield a wide range of achievements or performances.

Besides the linguistic capacity, another capacity that differentiates man from sub-human creatures is his technological capacity. It is no wonder that the two most widely known definitions of man are 'sign-using animal' and 'homo technikos'. Interestingly enough, both these capacities are expressive and promotive of human freedom. In terms of signs and symbols man expresses his experience, objectifies and communicates the same to others, and thus enlarges his world. Similarly, in terms of his mastery of technology he performs or achieves what he cannot ordinarily get done by his own bio-psychological capacities. Both these capacities expand the human world. Besides, the freedom made available by language and technology enables man to see clearly the relationships between the different areas of the world, physical, biological, epistemological and axiological and also the corresponding branches of knowledge. In short, language and technology, born out of human nature, enlarge and enrich its capacities in very many significant ways. Like medicine, which cures human diseases, language and technology remove the limitations of the impaired human capacities. In a way all these branches of knowledge make it clear how our realm of freedom can be effectively expanded and viewed as the basic principle unifying different branches of knowledge, pure and applied.

VII

Liberal historians and historiographers have often described history as the story of liberty. What they mean by this is that the course of history in different cultures is marked by increasing assertion of freedom, despite its occasional setbacks or regressive shifts. That history is not subject to any set of inexorable general laws is generally agreed upon.

But this highly general libertarian characteristic of history is not uniformly evident in different areas of history. First, universal history, the history of mankind taken as a whole, is more a generalisation than a description of the specific events of widely different national or local histories. Secondly, historians of highly abstract disciplines like mathematics and historians of culture-specific fine arts, for example, cannot for obvious reasons follow the same methodology. In the former case, *general patterns* are easily discernible, while in the latter, artistic *peculiarities* tend to arrest the historian's professional attention. Thirdly, histories of all branches of knowledge—physics, biology, earth-science, architecture, etc.—have their own *internal* and peculiar problems and issues. The same point may be raised in the contexts of economic history, technological history, history of ideas and history of philosophy. It is of considerable interest to note that

the very general nature of philosophy and of the influential ideas cannot make the concerned historians blind to their epoch-specific or culture-specific characteristics. Rightly analysed, this point indicates the necessity why all forms of history—from the very abstract to the very concrete, from the universal to the local—need to be studied in relation to their attending circumstances, physical, technological and cultural.

Interdisciplinary historical approach to different modes of human experience and action and their theoretical articulations should take human existence in its physical setting as its starting point. In a sense every starting point, physical, biological, or abstract philosophical, may appear arbitrary. But the main merit of taking the physical geography of man's existence as the first premise for understanding the unfolding of the history of human life, its problems, attempted solutions, and the resulting achievements is to show clearly how even the rudiments of our reflective life, 'primitive' technology, myth, different forms of folk culture, etc., are closely interrelated. From geology and geography to theology and metaphysics, every discipline is, directly or indirectly, traceable to the concerned man's experience of his own environment.

Human life, together with its culture, is itself an *orderly* disclosure, or evolutionary product, of Nature. Nature without *order* could not possibly account for the emergence of *homo erectus* and the finest flowers of its culture, science, mathematics, music and philosophy. The main areas of human experience and their theoretical formulations may be organised in very many ways. However, for the expository purpose one may perhaps profitably start with the physical sciences like physics, chemistry, geology, physical geography. Man's experience of his environment throws him back to his own self, his capacities and limitations. At this second level it is programmatically advisable to look into such disciplines as life sciences, including medicine, and technology. If through technology man's self-reflective nature tries to overcome its known limitations, he expresses, in and through language, what happens to him in his interaction with nature, conceptualises and communicates the same to fellow human beings. It is in this way that in terms of technology we not only exceed ourselves but also share our different forms of experience, knowledge and ignorance, joys and sufferings, with other human beings.

While the 'hard' physical sciences form the bottomline of our programme, the second upper line consists of relatively 'soft' life sciences. The more analytic-minded researchers may like to accord an intermediate position to such sciences as palaeontology, palaeogeography, and

palaeoanthropology. But this refinement, in principle, can be carried on indefinitely. The resulting taxonomy is not called for in the context of our research programming. For example, in between life sciences and social sciences one may easily carve out a 'natural' place for such disciplines as biosociology and demography. Thirdly, above the Nature—and Life—related sciences our research programme is obliged to recognize such basic social sciences as anthropology, sociology, economics, history and their allied disciplines. It may be mentioned here once again that in a pre-theoretical way the elements of all these disciplines are available even at the primitive level of life, the pre-civil state of society. The institutions and organisations that are theoretically studied at the third level are in a way experienceable also at the first and second levels. Even the sub-human creatures, including insects, have their own community life. The 'community life' of the ants in ant-hill or of the bees in bee-hive is more than an empty metaphor. Obviously the forms of our community life, unlike theirs, are consciously changed and flexibly adjusted in the light of our changing needs and experience and by our thought and action.

Beyond the level of social sciences we encounter abstract disciplines like mathematics, music, logic, epistemology, jurisprudence, etc. Careful scrutiny suggests that some of these disciplines are value-loaded and some others value-neutral. But, rightly understood, these characterisations, though welcome for the limited theoretical purpose, are not strictly tenable. For example, the very contemplation of some elegant and harmonious mathematical structures is historically reported to have provided deep intellectual pleasure and satisfaction to many experts in the field. From the other end it may be pointed out that sensuously enjoyable music has its own stable but refined mathematical base.

Finally, philosophy is often said to be the most comprehensive form of knowledge in which all other modes of experience are reviewed in an inter-related way. But about this proclaimed primacy of philosophical modes of knowledge one may critically observe that this sort of comprehensiveness is also available, though in a very speculative or inarticulate form, at the pre-theoretical level of mythology. As mentioned earlier, Indian and Greek cosmologies are also proto-scientific attempts to explain many in terms of one, water, fire, or air. In the modern forms of cosmology or philosophy the ancient forms of mythology are sought to be recapitulated and rearticulated in contemporary idioms.¹¹

Our research programme may be briefly and roughly indicated in the following diagram:

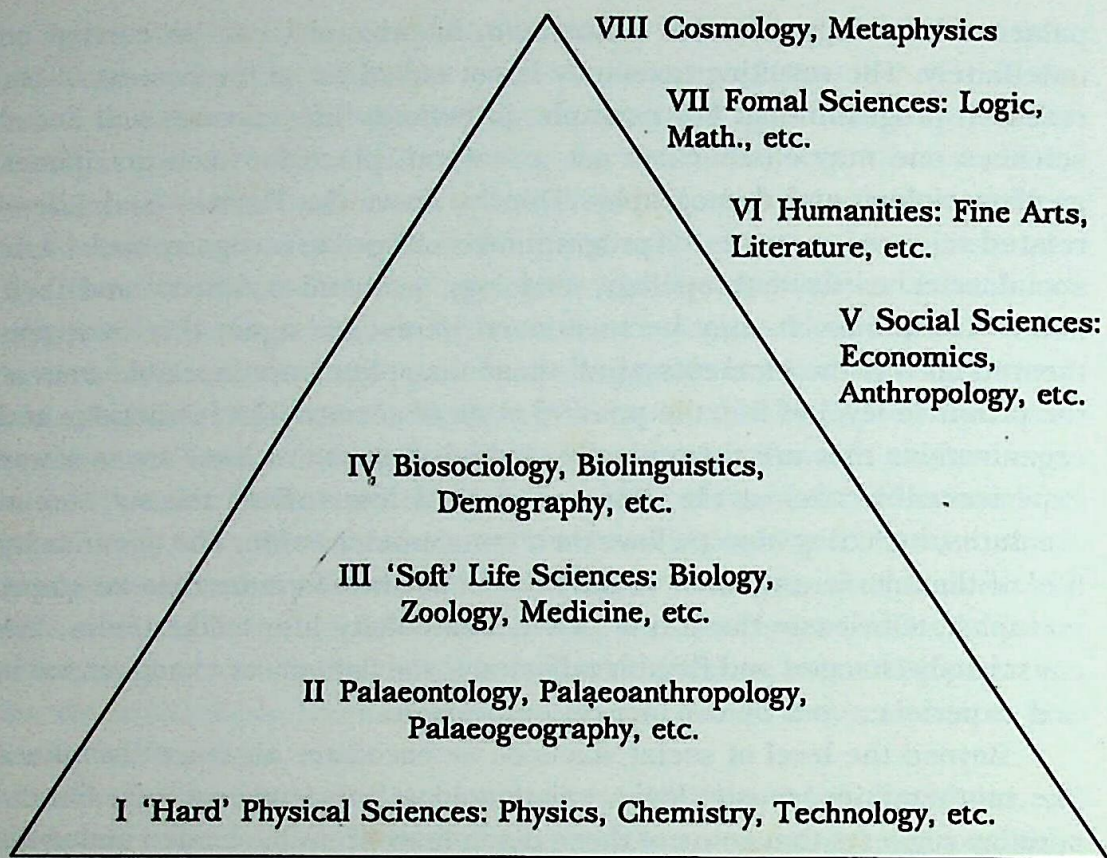


DIAGRAM 1

As it has been said earlier, this diagrammatic representation may easily be further refined and improved. However, the more important point is to recognize the alternative way of representing the programme. Broadly speaking, the whole diagram may be put upside down. Instead of moving from bottom to top, one may propose to move from top to bottom. In that case the so-called higher level disciplines like philosophy and mathematics take a reverse or bottom place. Moreover, the character of 'abstract' discipline is taken in a different, i.e., commonsensical manner. This point has been repeatedly conceded in the explication of the structure of Diagram 1. Given these qualifications, the second diagram of our programme may be visualized in the following way.

Diagram 1 is pro-naturalist and bottom-up and the reverse is the case with Diagram 2. The latter is anti-naturalist and top-down. Those who accord methodological primacy to natural sciences are generally found to favour the approach underlying Diagram 1. At the same time, many historians maintain that ideas and ideals, cognitive and praxiological, have proved more influential than physical forces and material factors of economic production in moulding the career of human civilisation and culture. This difference of

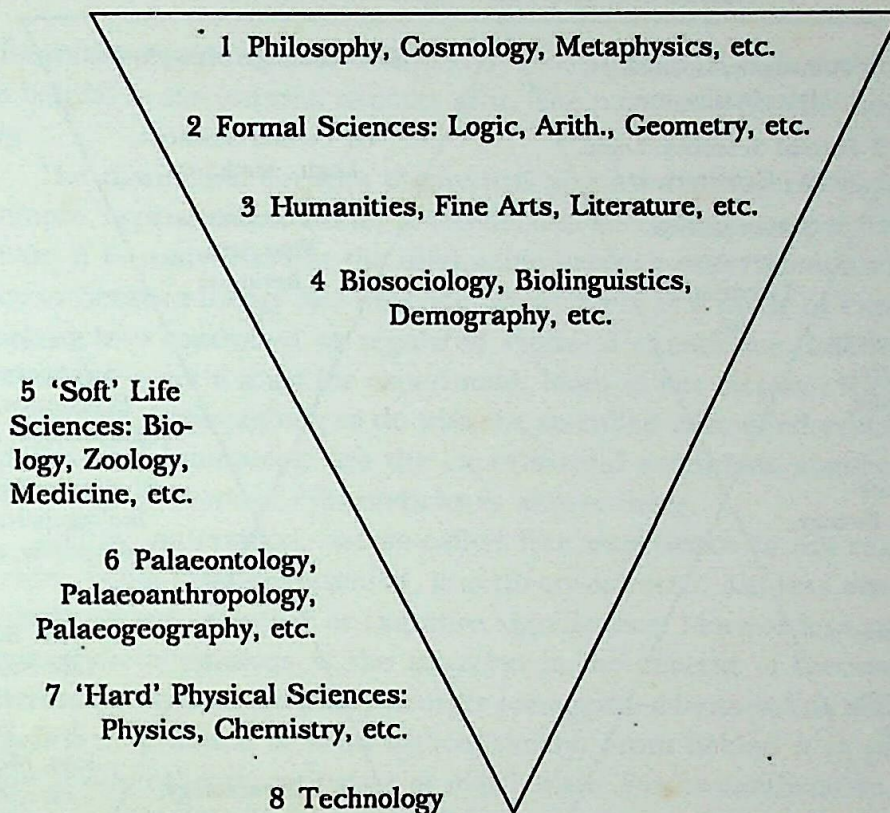


DIAGRAM 2

approach is not merely a matter of methodological primacy but it has also its ideological orientation. The scene appears doubly complex when we find that some of those who methodologically favour the bottom-up approach (Diagram 1) are ideologically libertarian (Diagram 2). In other words, the pro-naturalist historian of science, technology, philosophy and culture can also plausibly argue to show the supervening influence of ideas over the material factors of life. One may be naturalist, to start with, and yet end up an anti-naturalism or libertarianism. A sort of emergentism underlies the match between methodological naturalism and ideological libertarianism.

The substance of the third approach can be indicated by the following (somewhat complex) Diagram 3. In effect, this diagram is a combinatorial outcome of the Diagram 1 and Diagram 2.

Perhaps a word of qualification is called for at this stage. Diagram 3 is not a mechanical mix-up of the underlying ideas of Diagram 1 and Diagram 2. It is qualitatively richer and structurally more complex than the other two. For when the seemingly incompatible concepts of (methodological) naturalism and (ideological) libertarianism are harmonised

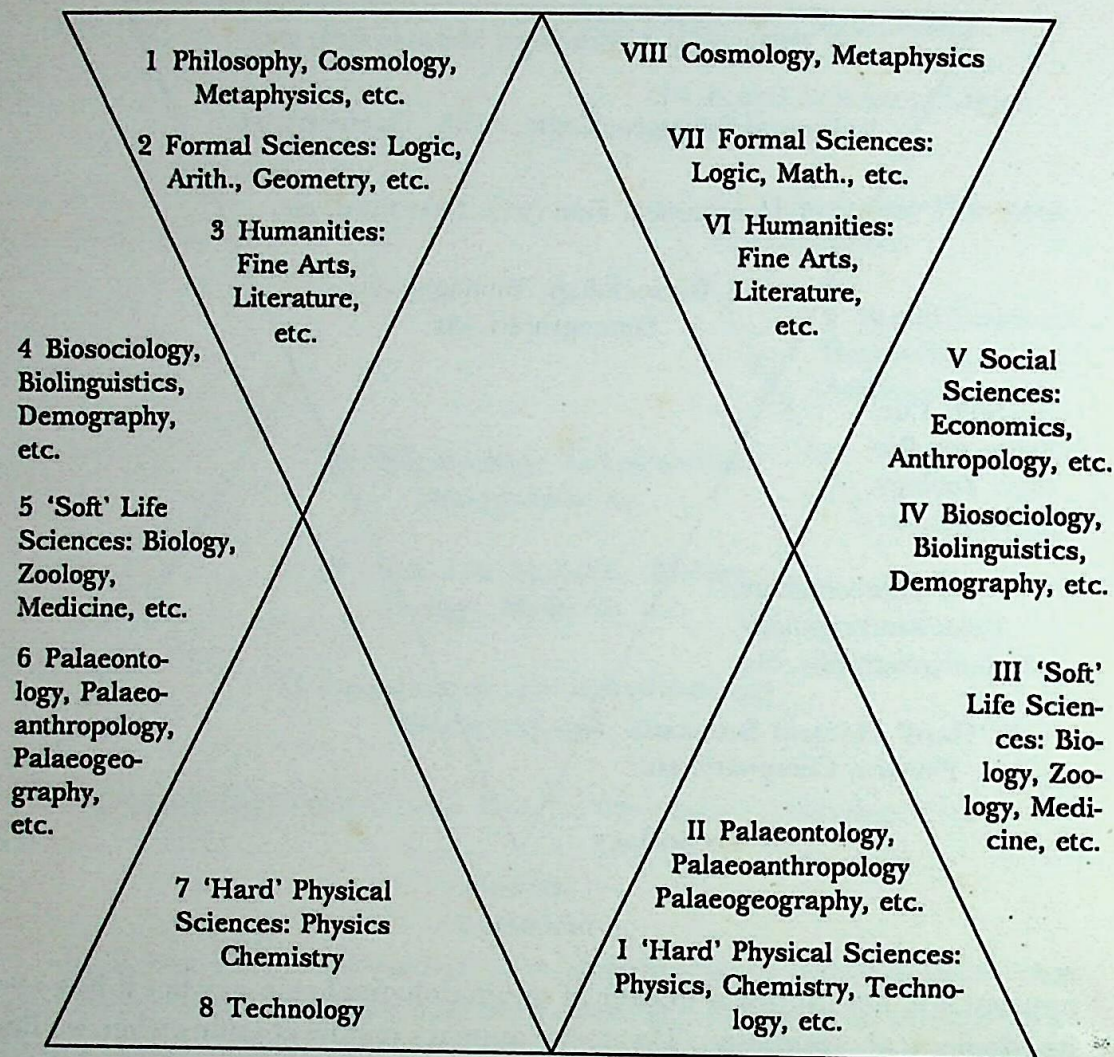


DIAGRAM 3

in terms of some or other form of emergentism, the whole approach assumes a character of added concreteness and comprehensiveness. If the underlying ideas of Diagram 3 strongly commends itself to us, it is mainly because of its organic or coherent nature, imparting clarity to the understanding of inter-relationships between different branches of knowledge and skill.

If we can properly follow the rationale of the composite programme of understanding the relationship of science and technology, their human roots or presuppositions become clearer to us. To think of technology merely in terms of skill, instrumental use of application one is doubly mistaken. First, it does not present us the full content of technology and, secondly, what is worse, the partial content that is highlighted by the 'skill' views or the means value of technology is highly distorted. The cognitive aspect of technology

is forgotten or inadequately realized by those who harp *exclusively* either on the helpful or the harmful aspects of it. The point may be clarified in this way.

The distinction between theoretical physics and applied physics, for example, is primarily a matter of intellectual and administrative division of labour. It is somewhat like the distinction between experiment and experience or between theory and practice. Experiment is a mode of experience, more or less controlled or regulated mode of experience. Laboratory or instrument is not a must for experiment. Many of our dietary experiments, for example, have nothing to do with the so-called controlled conditions of experimental laboratory. Are the experimental conditions absolutely controlled? An element of cyberneticity is always there.

Rightly understood, our so-called free experience is not really free. Besides being problem-oriented, it is theory-oriented. Aimless observation is hardly of any scientific or cognitive significance. More or less similar or purposefully anomalous is the situation in the context of theory-practice relationship. As hinted earlier, theory is presupposed by as well as anticipative of practice. Practice is blind without theory. From behind it is guided by some or other theory, articulate or inarticulate. For its continuation, to save it from possible disruption or breakdown, practice needs some cognitive or information input.

These general truths, unless suitably refined in appropriate cases and levels, are not of much help in clarifying our understanding of different areas of theory and practice. For example, on the very nature of the primitive or base concepts and organizing principles writers are not unanimous. Some maintain that physics and its laws provide us the basis of all other forms of knowledge. Some defend the primacy of biology. Some others think that all is consciousness at bottom. There are still other views regarding the basic theory of reality. Philosophy of different cultures abounds with such theories of uneven sophistication.

Some of these theorists are reductionist: some are not. The extremes of reductionism, observationalism and theoreticism, are often sought to be methodologically by-passed by different forms of evolutionary emergentism. Attempts are made to legitimize our commonsense recognition of such broad levels or categories of reality as matter, life and mind in terms of philosophical cosmology, monistic, dualistic and pluralistic or atomistic. An aspect of this legitimization is to be found in methodology, both experimental and speculative.

Neither methodology nor philosophy is functionally autonomous. Scientists are not at all unanimous in their formulation and choice of method.

Besides, intuition and chance factors are at times found to play significant role. Philosophers are even more divergent in their methodological and substantive commitments, no matter whether their background is mathematical, scientific, or humanistic.

Another point which deserves to be mentioned here is this. In some cultures, especially the 'primitive' ones, social conditions play a big role in the conception(s) of science-technology-philosophy relationship. The individual autonomy of the scientist and the philosopher, disturbingly enough, is seriously interfered with also in some 'modern' societies which are dominated openly or in a veiled manner by some or other political ideology.¹²

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History of Science in Relation to Philosophy and Culture in Indian Civilization

S. N. SEN

The *raison d'être* of the Project of History of Indian Science, Philosophy and Culture has been admirably set out in the blue book and further clarified in two notes by Prof. D.P. Chattopadhyaya 'On the Nature of Inter-connection between Science Technology, Philosophy and Culture'.¹ Prof. Ravinder Kumar's 'Reflections', largely based on the experiences of European scholars and his ideas on the peculiarities of the Indian situation, have added further dimension to the conceptual side of the project.²

For an overview of the relationship between science (including technology), philosophy and culture it seems to me necessary to explore the Indian understanding of, and attitude to, science over the ages and the conscious appreciation, if any, of the relationship of this science with the other activities and concerns, intellectual, philosophical, social, economic and so on, which taken together constituted the culture. In this exploration I shall endeavour to emphasize some of the characteristics of science in the sub-continent as it developed during the ancient and part of the medieval period.

MEANING OF SCIENCE

For this purpose I shall adopt a simple definition of science as a 'system of behaviour by which man acquires mastery of his environment'.³ This system of behaviour comprises man's knowledge and skills. With these two, human societies make and enlarge their environment for the betterment of

their lot. The ideas of science as knowledge of principles and facts, ordered knowledge of natural phenomena and of their relations or what is implied by the word 'Wissenschaften' developed later through growing internal sophistication. Although I have included technology within science I am aware of the distinctions sometimes made between the two. All that I mean to say is that science and technology are parts of the same spectrum differing in wave lengths. This may not be obvious in the so-called pre-scientific age when technology was more articulated than science, but the superficial distinction disappeared with science coming into its own.

It is also pertinent to bear in mind that the behaviour by which man acquires the mastery of nature is very much an inseparable part of his evolutionary history. In this evolutionary process from the primate stage to *Homo sapiens* his brain became considerably enlarged, in which the space devoted to the sense of sight increased and that to the sense of smell decreased, his eyes advanced from the sides to the front of the head making possible stereoscopic vision, and the *foramen magnum*, the opening for the passage of the spinal cord and blood vessels to the brain, moved to a more central position leading to the direct placement of the head on the spinal cord and consequently to an erect posture. The achievement of the upright carriage was of great significance as it freed the hands which, with the evolution of opposable thumb and the coordinating function of the brain, was responsible for the emergence of man as *homo tekhnikas*. This evolutionary process took place slowly over a vast stretch of time, from the Cenozoic to the Pleistocene, at the end of which appeared the 'knowing man' with a large brain, the neo-pallium. 'Here, housed within the curved bone plates of the skull, is the most subtle and complex instrument in the world, which, at the command of the whole man, has created the rich and varied cultures, the superb individual works of art, the inspiring if never final systems of thought, that make the history of mankind.'⁴

SOCIAL ORIGIN OF SCIENCE

We shall consider two proto-historical civilizations, namely the Bronze Age civilization of the Indus Valley and the Vedic civilization to make out the social origin of science. Both are well-defined in space and time. The first one whose script is yet to be fully deciphered to be of value for historical analysis has yielded abundant archaeological material to provide a good glimpse of the role played by technology in developing its culture and civilization. The other one with comparatively poor archaeological material,

the earliest specimen of the Indo-European group of languages, from which to analyze the relationships among science, philosophy and culture, has provided an immense yet unified literature.

The Indus Valley Civilization

Until 1947 the proto-historic culture unfolded at Harappa and Mohenjo-daro, result of a brilliant series of excavations started by Daya Ram Sahni in 1921 and R.D. Banerjee in 1922-23 and followed up by Vats, Dikshit, Marshall, Hargreaves, Mackay and others was believed to have been confined to a narrow strip of the Indus valley. Archaeological explorations carried out since then have now confirmed the geographical spread of this civilization over an area of about 840,000 square miles.⁵ This area includes East Punjab and Uttar Pradesh almost up to Delhi, northern Rajputana in the former State of Bikaner, Cutch, Saurashtra and Gujarat up to the mouth of the Narmada and the Makran coastal area in South Baluchistan up to Sutkagen Dor near the Iranian frontier. Marshall had originally estimated 3250-2750 BC as the period of the Harappan culture. This was later scaled down to 2350-1770 BC by C.J. Gadd and to 2500-1500 BC by Wheeler for the entire Harappan span. The lower datings have been confirmed by D.P. Agrawal and others, through radio-carbon methods of estimation largely carried out at the Tata Institute of Fundamental Research. The maximum spread for the metropolitan Mohenjo-daro, according to TIFR, might be taken as 2300-2000 BC and for the peripheral regions between 2200 to 1700 BC.⁶

Wheeler summarized the general characteristics of this civilization as comprising thick red-slipped wares in cylindrical and goblet shapes with geometrical and artistic designs (intersecting circles, pipal leaves, rosettes, and peacocks as motifs), seals and scripts, triangular terracotta cakes, kidney-shaped inlays of shell or faience, metal tool types, and town-planning according to a gridiron scheme of streets and houses.⁷ A cultural uniformity, unquestionable technical competence and a flair for standardization are unmistakable in all areas of activity—in the making of bricks in sanitary arrangements, in pottery, in the wide range of copper and bronze objects such as tools, vessels and human and animal figurines, and seal-cuttings from steatite blocks. In this effortless competence of which evidence has survived in archaeological remains of all descriptions one can see the picture of city-centred prosperous agricultural communities thriving on wheat, barley, sesamum and mustard, animal husbandry, an industry of woven cotton, various arts and crafts and an extensive trade, all rendered possible by an efficient central government with capitals, docks, harbours and defensive city outposts.

Agriculture and Irrigation

Gordon Childe's generalization that agriculture and irrigation were introduced for the first time in neolithic societies and then advanced from subsistence agriculture to a food producing economy in the more developed river-valley civilizations has been helpful in understanding the role of agriculture and irrigation in the Indus economy. Evidence in this regard has come from Baluchistan and the Indus valley where agricultural progress has been traced from the neolithic mid-fourth millennium BC to the chalcolithic 1st millennium BC; the remains of the main crops produced included wheat (*Triticum compactum*), dwarf wheat (*T. spaerococcum*), barley (*Hordeum vulgare*), dates, sesame and legumes.⁸ In West India and North Deccan, typical neolithic/chalcolithic rice husks have turned up at Lothal and Rangpur and wheat at Navdatoli and Songaon together with remains of lentils, green gram and myrobalan. The Ganga valley of the period 1st millennium BC has yielded remains of wheat and rice. While South Deccan has produced evidence of the cultivation of horse gram (Tekkalakota I), green gram (Paiyampalli) and millet (*ragi*) (Hallur). The finds of *Triticum* wheat from neolithic Burzahom and Chirand to chalcolithic Navdatoli and Songaon to early historical Nevasa and Ter present a consistent picture of the progress of wheat cultivation in the sub-continent, following its earlier evolutionary history in neolithic Jarmo-Jerico and West Iran. The oldest rice (*Oryza*) specimen has come from chalcolithic Vaidyapur and Chirand (radio-carbon date 4530 BC); finds are continuous throughout the chalcolithic phases up to the early centuries of the Christian era.

As to irrigation, a system of *gobarbands* for channelizing water and silt from hill streams to semi-terraced areas used to be practiced in Baluchistan. In Indus irrigation river inundations were utilised. From the Deccan we have evidence of terrace agriculture. Tank irrigation was popular in historical times in south India. The appearance of the use of the Persian Wheel in connection with well-irrigation was an important technological advancement. Thapar has suggested that irrigated rice agriculture together with plough agriculture, enforced by the former, was responsible for the growth of a dense population, and urban centres and the rise of a monarchical system.⁹

Fibres and Fabrics

The Indus civilization is also known for its skill in producing fibres or fabrics of wool, silk, linen and cotton. India appears to be the homeland of cotton from the Greek and the Babylonian use of *sindhu* and *sindon* for cotton. The

idea of making textile fabrics was possibly derived from the neolithic technique of making mats from reed or bamboo scrappings. Threads used to be made from the raw materials by twisting and winding the fibres with the help of a simple device, the spindle whorl. The whorls are circular objects provided with one or more holes and used as flying wheels in spindles. The materials for making them included terracotta, bone, shell, faience and stone. These devices have been unearthed from Harappa, Mohenjo-daro, Chanhudaro, Lothal, Kalibangan and a few other places. Cotton scraps, found at Mohenjo-daro, are of a coarse variety weighing 56.70 gm per 0.84 sq. m. Some of the terracotta sealings found in Lothal have impressions of packing materials made of cotton, thus providing an indirect evidence. Similar impressions of cotton fabrics are known from punch-marked coins wrapped in such materials and found in Bairat. Fragments of raw silk threads have turned up at chalcolithic Nevasa and Chandoli.

Metals and Metallurgy

Metals and metallurgy of pre- and proto-historic period naturally deserve special attention. Copper metallurgy appears in Iran by around fifty-four millennium BC. The appearance of this metallurgy in India is late by about 1000 years. A few copper pieces are known from pre-Harappan levels of Kalibangan, but the Harappa culture has yielded a rich collection of various sorts—knives, razors, chisels, arrow-heads, axes, fish-hooks, true saws, pots and pans. Copper is alloyed with tin for strength and ductility. Chemical analyses show that over 70 per cent of the artefacts were made of copper containing only 1 per cent tin, whereas the optimum percentage between 8 to 12 was found in only 14 per cent of the artefacts. This could be due to a general scarcity of tin.¹⁰ A number of samples yielded arsenic, nickel, and lead in varying percentages, which used to be alloyed with copper for increasing its hardness. Various metal forging techniques such as 'sinking', 'raising', 'cold working', 'annealing', 'riveting' etc., have been found to be evident in the samples of tools and pots. Further light on prehistoric copper technology has been thrown by the discovery of copper hoards, first made in 1822. These hoards which include antennae swords, axes, celts, rings, anthropomorphs etc., have been discovered over an extensive area—from Bengal to Gujarat and Andhra to Uttar Pradesh. Objects of the hoards were made of 98 per cent pure copper by a process of casting in single and double moulds, and then finished by hammering, chiselling, filing and tempering. Pure copper is difficult to cast, yet complicated casting of harpoons and other objects were carried out with the pure metal.

The Hittites are generally credited with the discovery of the process of smelting iron ores and the introduction of an iron age in the Caucasus or Asia Minor around 1800 BC. In the fifties, Col. Gordon, on the basis of a few iron objects, could place the beginning of the iron age in India around 250 BC. By 1959 Wheeler, on the basis of new evidence, was able to push it back to the sixth century BC. Now we know at least four distinct iron-using centres in the Indian sub-continent whose age varies from 700 BC to 1500 BC. The first region is the Indo-Ganga divide and the doab where, during 1940–44, a new type of pottery, the Painted Grey Wares (PGW), was discovered in layers associated with iron age occupations. This grey pottery is made of well-levigated clay free from impurities, and is medium to thin-walled and properly baked. Over 300 sites which have yielded this type of pottery include Ahicchatra, Alamgirpur, Atranjikhhera, Hastinapur, Ropar, Sravasti, Mathura, Kampil. The iron objects found in these P.G. layers include spears, arrows, points, socketed tangs, knives, blades, nails and slags suggesting iron smelting. For Atranjikhhera, the radio-carbon dating carried out at the TIFR has given a range from 1025 to 537 BC. The average range of C^{14} datings for all these P.G. level sites might be taken as 800–400 BC. The second area is Gujarat, Malwa and Central India where the iron age follows the chalcolithic period in a general way. In these areas (Nagda, Eran, Ahar) iron objects appear in association with Black and Red wares and include double-edged dagger, socket of an iron axe, spoon, axe, ring, nail, arrow-head, spearhead, sickle and so on. The C^{14} datings are 1040 ± 110 , 1270 ± 110 , and 1239 ± 71 BC for Eran; 1100 BC for Nagda; and 1500 BC for Ahar near Malwa which gave iron objects and slag. The third area is the middle and lower Ganga valley which has yielded post-chalcolithic iron microliths, ore samples and slag in large quantities. The prominent sites are Pandu Rajar Dhibi, and Mahisadal, both in the Ajay valley and Chirand and Sonpur. The radio-carbon dating has established a period 750 to 700 BC. The fourth source of prehistoric iron is the megalithic settlements in South India (Hallur, Tekwada, Brahmagiri, Piklihal) where iron objects were associated with urn burials. Hallur has given C^{14} datings at 1105 and 955 BC. The easy availability of iron ores in plenty, the sufficiency of primitive clay furnaces for smelting operations and the tribal experience of smelting ores to get the metal established by modern anthropological research provide a clear explanation of the appearance of iron in India from towards the end of the second millennium BC. Chakrabarti thinks that the advent of iron in India need not be associated with the supposed destruction of the Hittite monopoly of the iron technology and the coming of the Aryans to India. The discovery of iron-smelting in Thailand (Ban Chiang) between 1600 and

1200 BC already questioned the belief in a unitary origin of iron technology. The high antiquity of iron in India now suggests the possibility of regarding the sub-continent as an independent early centre of iron technology.¹¹

Weights and Measures

The enormous variety of objects of technical significance points to a complex culture. Technological efficiency, it is needless to emphasize, depends to a large extent on the development of an adequate system of weights and measures and consequent standardization. The Indus valley civilization provides us with ample evidence of such weights and measures, including balance pans, rods, and graded linear measurement scales. Mohenjo-daro, Harappa, Kalibangan, Lothal, Rojdi, Ropar and Surkotada have yielded weights in various shapes. A late Harappan specimen from Bargaon is cubical in shape, neatly cut and smoothly polished. The weights found at Lothal are in the simple ratio of 2, 4, 6, 8, 16. Hemmy found that the weights from Mohenjo-daro and Harappa followed a binary system in smaller weights and then decimal. Chalcolithic settlements in central and north Deccan (Maheshwar, Navdatoli, Nevasa) have yielded a number of spherical, cylindrical or discoid balls, packed and smoothed all over. They bear a simple, but different ratio of 1, 2, 4, 6, 8. Weights made from copper, agate, chert, diorite, granite, jasper and terracotta have turned up in the early historical period from Taxila, Charsada, Besnagar, Eran, Rang Mahal and other places. These weights are again in a binary sequence, 1, 2, 4, 6, 8, 16 etc., the average unit being 52 or 53 gram.

As weighing devices, a terracotta toy balance is known from neolithic levels at Chirand. A Harappan site (Surkotada) has yielded bowl-shaped pan, with perforation for suspension. Scale-pans of copper have come from Taxila. Weighing rods are depicted in sculptures typical of Nagarjunakonda and Gandhāra region. Kalibangan and Lothal produced scales with graded linear measurements. Another broken piece of shell which served the purpose of a scale was discovered in Mohenjo-daro and carefully analyzed by Berriman.¹² The fragment measures 6.62 by 0.62 cm and shows nine parallel lines, 0.264 in, apart, cut with a fine saw. Measurements showed that the Indus inch was equivalent to 1.316 or 1.32 in. Following Flinders Petrie's work, Berriman established the Indus inch to be equal to 2 Sumerian shusi. Another interesting feature was the demonstration that Indus inch multiplied by Greek finger equalled 1 sq. in. Does it mean that a Babylonian tradition had some role to play in the development of the Indus inch and later on upon the Greek finger metrology, to make possible such identity?

Summarizing the technical achievements of the Indus civilization, Bridget and Raymond Allchin quoted Gordon Childe and made their own observations as follows: 'As Gordon Childe so rightly pointed out, India produced "a thoroughly individual and independent civilization of her own, technically the peer of the rest", although resting upon the same fundamental ideas, discoveries and inventions as those of Egypt and Mesopotamia. We are now in a position to add to his statement that the extent and uniformity in terms of town-planning, crafts and industries, of the Harappan culture, far exceeded either. The most important single discovery must have been the exploitation of the Indus flood-plains for agriculture, offering a vast potential production of wheat and barley.'¹³

Sciences—Astronomy, Medicine

Even in the present state of imperfection in the decipherment of the script on the seals, the animal figures and pictographs appear to credit the Indus people with certain astronomical knowledge. In the seventies, Parpola and his group and S.M. Asfaque carefully examined these animal figures and concluded that these represented a crude system of the lunar zodiac and its divisions.¹⁴ Following the concept of the sky being surrounded by an ocean or a river and the stars swimming in it like so many fishes, the fish sign (⊙) has been associated with the Dravidian word *min* and its homophone meaning an asterism. Another seal (M. 2430), found at Mohenjo-daro, depicts a deity at the centre under the branches of a pipal tree, a kneeling priest, seven human figures, and a fish symbol, which has been interpreted as a new year festival such as is met with in the Vedic *saṃhitās*. Parpola at first thought of the seven human figures as representing the seven sages of the Great Bear, but later on revised his view in favour of the seven stars of the Kṛttikās (Pleiads) marking the vernal equinox.

Evidence of concern for medical remedies, health and hygiene is rare, but cannot be altogether ruled out from howsoever little has survived among these prehistoric ruins. There is positive evidence in favour of the use of horns of animals and fish-bones for remedial purposes. The horns of the stag of the special variety known as *Sambar* may be mentioned; the use of such horns in powdered form for therapeutic purposes appears in later Sanskrit pharmacopoeia. The cuttle fish-bones discovered in potteries excavated by N.G. Majumdar provide another example. *Śilājatu* or bitumen was a commonplace drug which came down to classical medical pharmacopoeia. But all these stray examples are surpassed by the large number of public baths, including the great bath of Mohenjo-daro, which were clearly designed for

safeguarding public health and possibly also for hydrotherapy. It may be argued that these baths were probably introduced more for religious purposes of ablution than for public health. The suggestion for hydrotherapy finds some confirmation with the emphasis placed in classical *āyurveda* texts upon the practice of regular baths, fomentation etc., from hygienic considerations. Suśruta and Caraka both elaborate on the merits of bath and prescribe treatment by fomentation and perspiration (*sveda*) in order to pacify or excite various vital elements of the organism.¹⁵

The Vedic Civilization

The four *Samhitās*, their *Brāhmaṇas* and *Āraṇyakas-Upaniṣads*, in various recensions, constitute the principal source of this civilization. The language of this vast literature is 'Vedic Sanskrit', or 'Ancient High Indian' as Winternitz proposed to call it, from which Sanskrit of the classical period, aided by Pāṇini's grammar, evolved. This literature was produced in the course of nearly a thousand years from the middle of the second millennium to the middle of the first millennium BC. Chronologically, the *Samhitās* are older than the *Brāhmaṇas* and the *Brāhmaṇas* older than the *Upaniṣads*, although some of the *Brāhmaṇas* are older than or contemporaneous with some of the *Samhitās*, and some of the *Upaniṣads* older than the *Brāhmaṇas*. The Vedic literature proper is immediately followed by another important group of literature, the *Vedāṅgas*, which deal with six special branches of knowledge, namely phonetics (*śikṣā*), ritual (*kalpa*), grammar (*vyākaraṇa*), etymology (*nirukta*), metrics (*chandaḥ*) and astronomy (*jyotiṣa*). These auxiliary sciences arose within the Vedic schools themselves to facilitate the study of the Vedas. The extent of the area covered by the civilization cannot be definitely ascertained. From the internal evidence it appears that the Vedic people were acquainted with the rivers of the Punjab, the Ganga and the Yamuna and a considerable part of South India evidenced by the influx of many Dravidian elements in the language. Nevertheless, the Sindhu-Ganga systems constituted the main centre of their civilization.

Vedic Society and Culture

Dominated by hymns, prayers, invocations, sacrificial and magical formulas and elaborate ritualistic procedures, the whole literature is regarded as the sacred texts of the *Brāhmaṇas* embodying their religious beliefs and practices. Yet it contains enough materials from which to reconstruct their secular interests, patterns of their social organizations, economic condi-

tions based on agriculture, arts and crafts, trade and commerce, their attitude towards life and nature, and their emphasis upon knowledge and science. Indeed, the word *Veda* means 'knowledge', and for that matter, 'knowledge *par excellence*'.

To start with the economic activities of the Vedic people, agriculture and cattle-rearing were the chief productive occupations of the society.¹⁶ Barley, wheat, beans and sesamum were the main cereals to be cultivated. In *Rgvedic* times rice was still unknown. There are several prayers devoted to the success of agriculture, which was yet to establish its importance in the economy. This role was enjoyed by cattle-rearing. According to one hymn of the *Atharvaveda*, the non-possession of the cows was considered as a great misfortune. The horse was highly valued. The *Rgveda* is full of prayers and invocations to gods for the grant of cattle and horses.

The profession of arts and crafts, smiths, carpenters, potters, weavers, tanners, and grinders of corn are specially mentioned. Later Vedic texts mention other skilled professions such as those of the fishermen, jewel-makers, washermen, rope-makers, barbers, bow-makers, wood-gatherers, boatmen, actors etc. The profession of physician is also explicitly mentioned. Considerable importance was attached to the wood-worker who was the carpenter, chariot-maker and cabinet-maker all rolled into one. Spinning and weaving probably attained a good standard as Vedic women wore brilliant and fine clothes. Metal industry flourished for the sake of weapons. The jeweller's profession was lucrative as gold ornaments and various kinds of gems were used by both the sexes.

Unlike the Indus valley civilization, trade and commerce did not flourish although land transport by bullocks, pack-horses, camels and wagons are referred to and river navigation and sea-going vessels are mentioned. We know from the *Atharvaveda* that there were three kinds of roads, one for chariots, another for carts, and a yet a third kind fit for travellers on foot. Sea-going vessels were propelled by oars and sails were probably unknown.

Scholars generally agree that the Vedic people, in the early stages of their development were worshippers of the powers and forces of nature. Many of the hymns of the *Rgveda* are not addressed to a sun-god, a moon-god, a fire-god, a storm-god or a goddess of dawn, of earth, and so on but to the shining sun, the gleaming moon, the blazing fire on the hearth, the roaring storms, and the glowing dawn, all natural phenomena already captivating man's mind.¹⁷ Dasgupta agreed that 'it was the forces of nature and her manifestations, on earth here, the atmosphere around and above us, or in the Heaven beyond the vault of the sky that excited the devotion and imagination of the Vedic poets'.¹⁸ These natural forces were gradually trans-

formed into mythological figures and into gods and goddesses presiding over natural phenomena. This deep concern for nature, its powers and mysteries no doubt led the Vedic bard to questions of cosmology, the origin of the universe, and the state of things before the creation, in the famous *ṛcās* of the *nāśadiya sūktā*:

नासदासीन्नो सदासीत् तदानीं नासीद्रजो नो व्योमा परोयत् ।
 किमावरीवः कुह कस्य शर्म न्मभः किमासीद्रहनं गभीरम् ।
 न मृत्युरासीदमृतं तन तर्हि न रात्र्या अहँ आसीत् प्रकेतः ।
 आनीदवातं स्वधया तदेकं तस्माद्वायन्न परः किं चनास ॥ (RV. X.11.1-2)

In Wilson's translation: 'The non-existent was not, the existent was not; then the world was not, nor the firmament, nor that which is above (the firmament). How could there be any investing envelope, and where? Of what (could there be) felicity? How (could there be) the deep unfathomable water.'

'Death was not nor at that period immortality, there was no indication of day or night; that one unbreathed upon breathed of his own strength, other than that there was nothing else whatever.'¹⁹

Apart from the creation mystery the hymn also foreshadows the monotheistic tendency (*tadekam*). There are several other hymns in the *Samhitās* and passages in the *Brāhmaṇas* containing germs of early philosophical speculations which further crystallized in the Upaniṣads.

Such an organized society based on agriculture, arts and crafts, trade and industry, characterized by a profound interest in nature and his physical environment, and moved by deep spiritual urges manifested in their elaborate sacrificial rituals provided a fertile ground for the cultivation of knowledge and science. The *Chāndogya Upaniṣad* gives a long list of sciences that used to be cultivated in the Vedic times.²⁰ Here we shall confine our remarks to astronomy (including mathematics) and medicine.

Astronomy and Mathematics

The social origin of astronomy, including mathematics, is clearly and consciously recognized by the Vedic literature itself. In the *Brāhmaṇa* literature, an astronomer is called a *nakṣatradarśa* (a star gazer) and at the same time a *gaṇaka* (a calculator or a mathematician). The use of the two terms appears to imply the importance of both observation and theoretical procedure (calculation) for the development of astronomy. The importance of mathematics and astronomy is emphasized in the *Vedāṅga Jyotiṣa* as follows: 'Like the crest on the head of the peacock and the gem on the serpent's

head, mathematics (and astronomy) lies at the head of all auxiliary sciences of the Veda.²¹ More importantly, the *Vedāṅga Jyotiṣa*, in one of its introductory verses, clearly states that astronomy is the science of reckoning time, this science developed because the sacrifices are to be performed in proper time and it is important to know the time. Therefore, he who knows astronomy also knows the sacrifices.²² Thus the calendrical science whose inspiration can also come from an agrarian society was in the case of the Vedic society stimulated more by the need for timely performance of sacrifices than by that of the seasonal harvesting of crops.

The nature of astronomical knowledge found scattered in the *Samhitās* and the *Brāhmaṇas*, clearly indicates that the development of a reliable calendar was the cardinal issue. For this purpose, the relative motions of the sun and the moon and their motions with respect to fixed stars were carefully investigated leading to the correct estimates of synodic and sidereal months, sidereal and tropical years, development of a stellar zodiac marked by 27 or 28 *nakṣatras*, the concept of the inclination of the ecliptic with the equator, the solstices and equinoxes, the variation of day-length between solstices and a solution of luni-solar adjustments through intercalation. The last problem was a continued headache and gave rise to different kinds of years with different modes of intercalation, making calendrical confusion sometimes the worst confounded. Thus we have in the *Nidāna Sūtra* and the *Latyāna Śrauta-sūtra* the following types of years:

- (a) The sidereal lunar year of 324 days—comprising 12 months of 27 days each.
- (b) The sidereal lunar year of 351 days—comprising 13 months of 27 days each.
- (c) The synodic lunar year of 354 days—comprising 6 months of 30 days each and 6 months of 29 days each.
- (d) The civil or *sāvāna* year of 360 days—comprising 12 months of 30 days each.

By the time of the *Vedāṅga Jyotiṣa*, a five-year luni-solar cycle (*yuga*) was evolved, during which the sun underwent 5 revolutions, the moon 67 sidereal revolutions and 62 synodic revolutions. It was estimated that the 5-years period contained 1830 civil days, 1835 sidereal days, 1800 solar days and 1860 lunar days or *tithis*. The solar year turned out to have 366 civil days, a synodic month 29.52 days and a sidereal month 27.31 days. For the post-Vedic period the legacy of the Vedic astronomy was considerable, but still insufficient. There was no way to predict the eclipses. The motions of the

star planets other than the sun and the moon were vague and unquantifiable. These necessitated the development of sophisticated mathematics—operation with large fractions, solution of indeterminate equations, geometrical models, trigonometry and spherical trigonometry and several important constants and parameters for which we had to wait for a new socio-economic and political situation during the first few centuries of the Christian era.

Like astronomy mathematics, particularly altar geometry, binomial series, originated in the Vedic rituals and general social and economic conditions. The Vedic Hindus already gave evidence of their striking interest in large numbers built up on the basis of 10 and its powers. Thus place names have been given up to *parārdha* (10^{12}). The *Pañcaviṃśa Brāhmaṇa* uses these numbers in fixing the *dakṣiṇās* for various sacrifices. The Jains imbibed this interest in large numbers from the *Brāhmaṇas* and went up to ten places of decimal and beyond. Their *tallakṣaṇa* is a number equal to 10^{53} . A familiar question which the Jains used to ask: What is the number of mustard seeds required to fill a hemispherical trough as large as the Jambūdvīpa with a diameter of 100,000 *yojanas*? Then there are other *dvīpas* and bowels of the oceans which are to be similarly filled with mustard seeds. The total number of mustard seeds will still be less than the highest numerable (*saṃkhyeya*). Beyond the highest numerable is the group called the innumerable (*asaṃkhyeya*) and beyond that the third group the infinite (*ananta*). This concept of large number gave a new dimension to Vedic and Purāṇic cosmology—the concept of an infinite universe, as against the medieval Latin European concept of a closed universe depicted in Dante's *Divine Comedy*.

The *Śulbasūtras* attached to the *Śrautasūtras* give us several geometrical rules and procedures for the construction of fire-altars in different geometrical shapes—falcon-shaped both rectilinear and with curved wings, isosceles triangle, rhombus, wheel with and without spokes, square, tortoise-shaped and so on. Each shape has a fixed area ($7\frac{1}{2}$ sq. *puruṣa*) and has to be covered with a fixed number of bricks (200) of different shapes. The meticulous observance of these rules for the exact construction of the fire-altars as prescribed in the text inevitably led to the formulation of geometrical rules for the construction of squares, right angles, transformation of a square into a rectangle or a triangle or a circle and vice versa, the estimation of the diagonal in term of the side of a square and so on. The rules led to the definition of the so-called theorem known after the name of Pythagoras, the irrational numbers, $\sqrt{2}$, $\sqrt{3}$ etc., approximate value of π .²³

Mathematical interest in permutations and combinations among the

Vedic Hindus also appears to be stimulated by considerations of Vedic meters and their variations. There are several Vedic meters, e.g., *Gāyatrī*, *Anuṣṭubh*, *Bṛhatī*, *Triṣṭubh*, *Jagatī*, etc., with 6, 8, 9, 11, 12 syllables. The Vedic meter specialists grappled with the problem of producing possible types of meters from those of varying syllables by changing the long and short sounds within each syllable group. Piṅgala's *Chandaḥ-sūtra* (200 BC) gives the rule of a method called *meru-prastāra* for the computation of the coefficients in a binomial series, which reappears in Europe as Pascal's triangle in the arithmetic of Apianus (AD 1527).²⁴

Medicine

If prehistoric archaeology has preserved for us evidence of concern for health and medicine, such evidence is much more pronounced in the Vedic *Samhitās*, *Brāhmaṇas* and the *Upaniṣads*. These sacred texts contain numerous references to the parts of the human body, several maladies and their remedies. Moreover, important seed ideas about the anatomy and physiology, concepts of elements, the special functions of water, fire and air in maintaining the organism are met with albeit in a rudimentary and disorganized form, which clearly appear to develop into a continuing tradition and eventually into a coherent and meaningful framework for a medical science. The magical strophes of the *Atharvaveda* and the various rites elaborated in the *Kauśikasūtra* of the *Atharvaveda* doubtless represent the early beginnings of the art of healing, at first by incantations and later on by the application of medicinal herbs. The *Rgveda*, *Atharvaveda*, the *Śatapatha Brāhmaṇa*, the various recensions of the Black *Yajurveda* and other texts are full of allusions to a large number of bones of the human body with accurate names and descriptions, many of which passed unmodified into later *āyurveda* texts. A pneumatic theory of physiology, if not a full-scale *tridoṣa* theory, was already in the process of formation during the period of the *Samhitās* and the *Upaniṣads*.

The term *āyurveda* meaning 'science of life' already came to be regarded as an *upaveda* of the *Atharvaveda* and sometimes as an *upaveda* of the *Rgveda* (*Caraṇavyūha*, 38; *Prasthānabheda*, IV). Suśruta agrees with this tradition and says that the *āyurveda* was not only an *upaveda* of the *Atharvaveda*, it was produced by Svayambhu in one hundred thousand verses distributed over one thousand chapters and divided into eight principal sections.²⁵ Caraka also maintains that the physicians should be devoted to the *Atharvaveda*, the *Veda par excellence* as far as the *āyurveda* is concerned.²⁶

The *Caraka*, *Suśruta* and the more ancient *Bhela-Samhitā* made their

appearance in the post-Vedic classical period, but continued the Vedic tradition in *āyurveda*. One unquestionable mark of this medical science is its unmistakable emphasis on the application of all branches of science. Its multidisciplinary character is manifest in its eight-fold divisions such as surgery, treatment of diseases, children's diseases, toxicology, science of rejuvenation, science of aphrodisiacs, and demoniacal diseases. Dispersed within these broad divisions and discussions of subjects like general biology, animal biology, genetics, gynaecology, obstetrics, personal hygiene, preventive treatment and social medicine, botany, food and nutrition, chemistry, psychology, climatology, cosmology, philosophy, religion and so on. Herbal remedies which occupied a major part of the *materia medica* naturally called for a deep knowledge of plant science or botany. Suśruta mentions several salts, discusses methods of preparation and an elaborate account for the extraction of alkalis from plant sources, making these works an indispensable source of our early knowledge of chemistry in India. The basic idea of the *āyurveda* is to understand man and nature as completely as possible as a *sine qua non* for keeping him in good health and curing him of diseases when afflicted. Suśruta advises that in order to be a successful physician he should be versed in many sciences—

न ह्येकस्मिन् शस्त्रे शक्यः सर्वशास्त्राणामवरोधः कर्तुम् ।

(Sū. IV.6)

Furthermore:

एकं शास्त्रमधीयानो न विद्याच्छास्त्र निश्चयम् ।।

तस्माद्बहुश्रुतः शास्त्रं विजानीयाच्चिकित्सकः ।।

(Sū. IV.7)

'A physician who has learnt one science only cannot be sure of his own science (*āyurveda*) and for this reason the physician has to be versed in many sciences.'

Suśruta was a surgeon. He naturally emphasized the importance of surgical treatment and mastering, for this purpose, the anatomy of the human body through dissection. In this connection he stressed the importance of actual observation instead of depending solely on the authority of text-books. He maintained that an ideal combination of theoretical knowledge gained through text books and practical experience through dissection was indispensable for advancement of knowledge. In his own words:

तस्मान्निः संशयं ज्ञानं हर्त्रा शल्यस्य वाञ्छता ।।

शोधयित्वा मृतं सम्यग्द्रष्टव्योऽङ्गं विनिचयः ।।

प्रत्यक्षतो हि यदृष्टं शास्त्रदृष्टं च यद्भवेत् ।।

समासतस्तदुभयं भूयो ज्ञानविवर्धनम् ।।

(Śā. V. 47-48).

'Therefore, he who desires to acquire the correct knowledge of anatomy, free from doubt, should process a cadaver and thoroughly examine (by dissection) all the various parts of the body. What is observed directly should then be compared with the standard text; (interaction between) the both (direct observation and textual observation) will lead to further increase of knowledge.' This reflects an attitude to anatomical science no less remarkable than what we notice in Vesalius and other Latin European anatomists of the sixteenth century just before the scientific revolution.

INPUT FROM PHILOSOPHY

Right and Valid Knowledge

In what way the development of philosophical systems in India, orthodox (*āstikas*) and heterodox (*nāstikas*), favoured or discouraged the growth of science is a moot question. Despite their different points of view, assumptions, premises, and dialectic positions, all systems were concerned with the right and valid knowledge, and therefore with ways and means of arriving at it. The followers of the *Pūrva-mīmāṃsā* who accepted the Vedic rituals and sacrifices as their *dharma* and philosophy, accepted the reality of the world, categories like substance, quality, sound etc., and placed reliance upon empirical experience. According to them, right knowledge or *pramāṇa* is obtainable by six types of *pramāṇas*, e.g., *pratyakṣa* (perception), *anumāna* (inference), *śabda* (verbal testimony), *upamā* (analogy), *arthāpatti* (presumption) and *abhāva* (non-existence). (प्रत्यक्षमनुमानं च शब्दश्चोपमया सह, अर्थापत्तिरभावश्च षट् प्रमाणानि. जैमिनैः). Jaimini accepted the first three types of *pramāṇas*; later on one of the two *Mīmāṃsā* schools accepted five excluding *abhāva*, and all the six *pramāṇas* were adhered to by the other. The *Mīmāṃsakas* took an active interest in the study of sound and its propagation and made important contributions to the subject.

The Realism of the Nyāya-Vaiśeṣika

As a scientific system of logic, independent of religious beliefs, the importance of the *Nyāya* and the *Vaiśeṣika* systems, later on syncretized as the *Nyāya-vaiśeṣika*, need hardly be over-estimated. According to Vātsāyana, the *Nyāya* is concerned with things doubtful; it is neither concerned with things unknown nor with things definitely known—तत्र नानुपलब्धे न निर्णयितुं न्यायः प्रवर्तते किन्तिर्हि संशयितेत्यर्थः ।। (NBh. 1.1.1). Doubtful objects, Vātsāyana continues, are to be examined by evidence—प्रमाणैरर्थं परीक्षणं न्यायः (NBh. 1.1.1). The *Nyāya*

stipulated sixteen categories of evidence for arriving at right knowledge, such as *pramāṇa* (means of right knowledge), *prameya* (objects of right knowledge), *saṃśaya* (doubt), *prayojana* (motive), *dr̥ṣṭānta* (examples), etc. The *Vaiśeṣika* system, considered to be older than the *Nyāya*, but which accepted the *Nyāya* syllogism, formulated only six categories—*dravya* (substance), *guṇa* (quality), *karma* (motion), *sāmānya* (universal), *viśeṣa* (differential) and *samuvāya* (inherence). Praśastapāda called these categories *padārtha* and defined it as that which is capable of existing (*astitva*), that which is namable (*abhidheyatva*), and that which is knowable (*jñeyatva*). This definition itself provided the clue to the realistic attitude of the *Vaiśeṣikas* to the world and nature as they saw it. They were interested in, and endeavoured to analyze, the physical reality of everything that is existent, knowable and namable and therefore, communicable to others. Their categorization of physical entities were clearly ancient and medieval, that is, pre-modern scientific which could only be handled with old epistemological process. With these concepts and methods the *Vaiśeṣikas* advanced as far as it was possible for any ancient or medieval culture to do. Modern physical sciences started appearing only when these categories were replaced by concepts of mass, momentum, force, energy and such other measurable entities and consequently when the method of epistem gave place to the experimental-cum-mathematical method.

Substance, Atomic Theory

To give a few examples of the *Vaiśeṣika* success, substance or matter was defined to be a substratum of qualities and motion, a physical category capable of providing inherent or material cause as well as self-subsistence. This matter is divided into five kinds of *Bhautika* matter, e.g. earth, water, fire, air and ether and four types of non-*Bhautika* matter, e.g., time, space, self and mind. Of these nine types of matter, earth, water, fire, air and mind are atomic and the rest are ubiquitous or non-atomic. Atoms are eternal, so matter is eternal in atomic state and non-eternal in the state of aggregation. Various physico-chemical changes in a body are brought about by various types of atomic aggregation. Complete disintegration of a body results from the breaking up of it into an atomic state. The mobility of the fluid is explained in an atomic theory. When a solid substance such as an ice block, or butter, or a piece of iron melts on the application of heat, atoms are loosened, that is, rendered relatively free from one another to produce fluidity. A black unbaked plastic earthen pot becomes red and hard when baked by processes called *pīlupāka* and *pīṭharapāka* for which an ingenious atomic explanation is offered.

The atoms (*paramāṇu*, *aṇu*), according to the *Vaiśeṣikas*, are thus the ultimate constituents of matter or substance. They are eternal and so do not admit of destruction. They are indivisible in the sense that they represent the ultimate reality at which the process of subdivision of gross matter must stop as a logical necessity. They have no material parts demonstrated through a discussion of the epistemological concept of whole and part. Atoms have the smallest magnitude (or dimension) and are spherical. Since their creation, atoms are in incessant motion imparted to them by *adrṣṭa* (unknown cause). The various attributes of the atoms, such as their partlessness, dimension, combining capacity to form diads etc. were seriously and bitterly controverted by the Buddhists, but the theory survived till the days of Neo-logical school of Bengal, undergoing certain modifications from time to time, but holding steadfast to its central concept.

Concept of Motion and Impetus Theory

The concept of motion was an enigma throughout antiquity and during medieval times. Aristotle whose ideas of motion dominated Latin Europe up to the time of Galileo used the term *kinesis* for motion, which meant the realization of a potentiality—*actus existens in potentia in quantum est in potentia* (*De Caelo*). He regarded motion as natural and unnatural, that is, forced. Terrestrial and sublunary elements possess their 'natural place' and therefore a 'natural motion' towards that place. Thus earthy bodies move naturally to the centre of the earth. Fire whose natural place is in the region of the sublunary sphere moves upwards. Natural motion of celestial bodies is circular and cannot be rectilinear because in that case they would fly out of the universe which is contrary to experience. (*De Caelo*, 1, 2, 3). For non-natural motion, Aristotle argues, a continuous application of force is necessary to keep the body in motion—*Omne quod movetur ab alio movetur* (all that moves is moved by some thing else). A motive cause or force called a *motor conjunctus* is required to act continuously on the body to keep it in non-natural motion. The theory breaks down in the case of a projectile such as an arrow or a javelin because the motion continues even when the *motor conjunctus* ceases to act. Aristotle was aware of the weakness of his theory and unsuccessfully tried to save the phenomenon by his concept of *antiperistatis*. In the fifth century AD. Philoponus criticized Aristotle's theory of motion and following his criticism, William of Oakham, Jean Buridan, Nicholas of Oresme, Nicholas of Cusa, in the fourteenth century, suggested an impetus theory (*vis impressa* of Galileo) which led Galileo to form his concept of force, acceleration, mass and their mathematical relationships.

In the *Vaiśeṣika* treatment of motion we do not find any kind of anthropomorphic or zoomorphic concept like 'natural place', 'natural motion', 'unnatural motion' etc. Motion is simply defined as that caused by conjunction and disjunction (संयोगविभाग-निरपेक्षकारणत्वम्) which simply means change of position or displacement. Such change of position can be brought about by gravity, fluidity, volitional effort and conjunction (गुरुत्वद्रवत्व प्रयत्न संयोगजत्वम्). Moreover, corporeal bodies can have motion (मूर्तद्रव्य वृत्तित्वम्) and a single motion can exist in a substance at a time (एकदा एकस्मिन् द्रव्ये एकमेव कर्मवर्तते). As causes of motion, gravity, fluidity, volitional effort and conjunction have been mentioned. Gravity is the cause of falling motion. Fluidity causes the motion of fluids. Forces of impact and pull are special types of conjunction. Thus impact or striking is *abhighāta* and impelling push *noḍana*. In addition to the above, there is yet another cause of motion, namely *vega*—वेगात् गमनम्। *Praśastapāda* explains that *vega* is a *saṃskāra* (impetus), the other two forms of *saṃskāra* being elasticity and mental impression (संस्कारस्त्रिविधो वेग भावना स्थितिस्थापकश्च). This *vega* which is a *saṃskāra* (impetus) is produced by motion, but not by any kind of motion. It is produced only by such motion as are caused by forces like *noḍana* and *abhighāta*. This *vega* has been interpreted as momentum or kinetic energy.²⁷ With this concept of *vega* and *saṃskāra*, *Praśastapāda* beautifully explained the motions of mortar and pestle, a javelin discharged by the hand and an arrow shot from a bow.

Sāṃkhya Theory of Evolution of Matter

By assuming atoms and atomic matter to be eternal the *Vaiśeṣikas* avoided the question of creation of matter. Their *ārambhavāda* concerned only the formation of gross bodies through atomic combinations. It is the unquestionable merit of the *Sāṃkhya* system to propose a theory of the origin and evolution of matter, in which they recognized the role of a certain energy principle. This is to be expected from the *Sāṃkhya*'s concept of *Prakṛti*, the ultimate ground, the very principle at the base of the universe. In its pristine state, *prakṛti* is formless, undifferentiated, unmanifested, unconscious, all-pervasive, indestructible and eternal. It is endowed with three constituents or reals called *guṇas* (quite different from *Vaiśeṣika guṇas*) which are in equilibrium with one another in the undifferentiated state. The grounds for postulating such an entity are: (a) since individual objects of our experience are all limited in magnitude, the final source of such limited objects must have unlimited potency; (b) this ultimate source must again possess a combination of pleasure, pain, and delusion which characterize manifested

objects; (c) the cause and effect relationship on which the *Sāṃkhya* places implicit reliance (कारणगुणात्मकत्वात् कार्यस्य—*Kā.* 14) ultimately leads to an entity which must be the uncaused cause of all things, physical or psychical; this argument is clearly stated in the *Sāṃkhyasūtra* as 'since the root has no root, the root (of all) is rootless' (मूले मूलाभावादमूलं मूलम् ।।—*Sūtra.* 67); and (d) the unmanifest cause does exist because specific objects are finite, there is a natural sequence, activity depends upon efficiency, cause is different from effect and the evolved things must have remained initially submerged (भेदानां परिमाणात् समन्वयात् शक्तितः प्रवृत्तेश्च । कारणकार्यविभागाद् वैश्वरूपस्य—*Kā.* 15). The primal Nature is the origin and non-product and an evolvent, because it is not produced from any thing, as is explained by Gauḍapāda in commenting upon *Kārikā*'s characterization—मूलप्रकृतिरविकृति । The non-apprehension of *prakṛti* is due to its infra-atomic character and not to its non-existence—सौक्ष्म्यात्तदनुपलब्धिर्नाभावात्—*Kā.* 8. Its existence is revealed through its products or evolves like *mahat* and the rest in the process of evolution. I am tempted to liken *Prakṛti* to the singularity of matter before the Big Bang.

The concept of three *guṇas* occupies the central position in the *Sāṃkhya* system. Like the original entity, these are subtle, infra-atomic, beyond sense perception and comprehensible only through the effects. The *Yogabhāṣya* calls them *māyā* because these do not come within visual range. The three *guṇas* are *sattva*, *rajas* and *tamas*. *Sattva* has the property of illuminating a phenomenon—सत्त्वं लघुः प्रकाशम् । Seal interprets it as the essence or the intelligent stuff.²⁸ *Rajas* is the dynamic principle responsible for the production of motion and is therefore an agent for overcoming obstruction and resistance—उपष्टम्भकं चळं च रजः । By virtue of its ability to do work, it is nothing but the energy principle. *Tamas* is the resistive principle opposing the tendency of *sattva* to illuminate and *rajas* to do work, and prefers to maintain the *status quo*. *Kārikā* describes it as गुरु वरणकमेव तमः and elsewhere as नियमार्थम् meaning स्थितौ समर्थम् । Seal calls this reality of *Prakṛti* mass or inertia. In the unmanifest state, these three reals are in perfect equilibrium. When this equilibrium is disturbed and one of the *guṇas* predominates over the other two, the other two compromise and cooperate in the final effect. This equilibrium is disturbed through the action of *Puruṣa* and the evolutionary process starts producing in a chain reaction *mahat* and *ahaṅkāra*, and subsequently from the three types of *ahaṅkāra* (*vaikhārika*, *taijasa* and *bhūtādi*) mind, the five senses and the five *tanmātras*.

The five *tanmātras* are of special significance in the physical world view inasmuch as the elements arise out of them. The five *tanmātras* are *śabda*, *sparsa*-, *rūpa*, *rasa*- and *gandha-tanmātras*, each associated with an energy

principle, e.g., vibration, mechanical pressure, radiation, viscosity, and cohesive attraction.²⁹ The *Sāṃkhya*'s creative process thus recognizes the role of energy in the formation of elements and their constituent atoms, Īśvarakṛṣṇa's cryptic statement *taijasādubhayam* is explained by Vācaspatimiśra as *rajasat*, 'from energy'. Furthermore, that energy is indestructible and conserved is implicit in the *satkāryavāda* of the *Sāṃkhya*.

Influence of Nyāya-Vaiśeṣika and Sāṃkhya on Medical Science

It is important to note that the medical sciences which were vitally interested in food, nutrition and therapeutics were naturally and deeply influenced by the logic and the concept of matter propounded in the *Nyāya-Vaiśeṣika* and *Sāṃkhya* systems. In the *Vimānashthāna* of his *Samhitā*, Caraka emphasizes the importance of applying *Nyāya-Vaiśeṣika* logic and the method of debating for the advancement of medical science as follows:

इमानि तु खलु पदानि भिषग्वादमार्गं ज्ञानार्थमधिगम्यानि भवन्ति: तद्यथावादः, द्रव्य, गुणाः, कर्म, सामान्यं, विशेषः, समवायः, प्रतिज्ञा, स्थापना, प्रतिष्ठापना, हेतुः, दृष्टान्त, उपनयः, निगमनम् . . . ।।

Vimāna. VIII.27.

In the *Śārīrasthāna*, Caraka presents a detailed account of the *Sāṃkhya* theory of creation, based on the views of Pañcaśikha, and gives the following reason why *Sāṃkhya* is relevant to medical science:³⁰

अत्र कर्मफलं चात्र ज्ञानं चात्र प्रतिष्ठतम् ।
अत्र मोहः सुखं दुःखं जीवितं मरणं स्वप्ना ।।
एवं यो वेद तत्त्वेन सं वेद प्रलयोद यौ ।
पारंपर्यं चिकित्सां च ज्ञातव्यं यच्च किंचन ।।

Śā. I.37–38.

'These (*sattva*, *rajas* and *tamas*) determine the actions, fruits of action, knowledge and ignorance, pleasure and pain, life, death and ownership. He who knows these principles knows creation and destruction, continuity, therapeutics and whatever is knowable.'

Suśruta too opens his chapter on *Śārīrasthāna* (anatomy) with an elaborate but succinct account of the *Sāṃkhya* doctrines as met with in the *Sāṃkhya-kārikā* and the *Sāṃkhya-pravacana-sūtra*—सर्वभूतानां कारणमकारणं सत्त्वरजस्तमो लक्षणमष्टरूपमखिलस्य जगतः सम्भवहेतुरव्यक्तं नाम । तदेकं बहूनां क्षेत्रज्ञानामधिष्ठानं समुद्र इवौदकानां भावानाम् ।।

Śā. I.3.

'The unmanifest (*avyakta*) which is characterized by *sattva*, *rajas* and *tamas* and by eight-fold categories is the cause and uncause of all created things and the very cause of the coming into being of the universal world.'

Negative Attitude of Buddhism and Vedānta

If the *Pūrva-mīmāṃsā*, the *Nyāya-Vaiśeṣika*, and the *Sāṃkhya*—to which we should also add Jainis with its *Syādvāda* logic, made some positive contribution to the development of physical concepts, the same cannot be said either of the Buddhism or of the Vedānta system of thought. The *Sāṃkhya-yoga*, the *Nyāya-Vaiśeṣika* and some other orthodox systems present us with a world view in which primordial matter is fundamental, atoms are permanent, and gross bodies evolve, metamorphose, transform and disappear in accordance with a causal relationship. In this view, substance with its changing qualities is a reality deeply ingrained in man's habits of thought. The Buddhists were basically opposed to such views. They denied substance, god, soul and eternity. About the reality of substance or matter and the external physical world the Buddhists, in their different schools and periods, had fundamental differences, but ultimately settled down to a doctrine of perpetual flux (*kṣaṇabhaṅga-vāda*), according to which the reality, as Stcherbatsky puts it, is a 'transient flow of evanescent events.'³¹

Three distinct phases have been recognised in the evolution of the Buddhist concept of reality and their attitude to the physical world. In the first phase, roughly from 500 BC to 0 BC, when Hīnayāna Buddhism was predominant, the Buddhists recognized the world as comprising two distinct characteristics, namely that (a) particulars arise from sense perceptions, e.g., form, sound, smell, taste and touch, and (b) consciousness is responsible for feelings, ideas and volitions (*vedanā*, *saṃjñā*, and *saṃskāra*). Being convinced of the impermanence of the human life, the Buddhists developed their fundamental formula of 'no substance, no duration, no other bliss than *nirvāṇa*'. The Buddhists of course talked of 'elements', but these were not the elements of the Upaniṣads or the *Sāṃkhya*. These elements were pluralistic, momentary sense-data and thought-data linked together in individual life. Stcherbatsky thought that the idea of momentariness was implicit in the concept of pluralistic elements. To explain the idea of momentariness, they developed the simple logical formula—अस्मिन् सति इदं भवति (this being that arises).

The Hīnayāna Vātsīputrīyas and some other schools did not regard the elements as so many unrelated entities and admitted certain unity among them. They were aware that admission of unity among elements was likely to lead to the idea of some kind of substancehood. They assumed an intermediate position in which human personality is neither identical with elements nor different from them, but is dialectical. The Sarvāstivādins, another Hīnayāna group considered the three elements of time—present,

past and future, to be real, and had to admit even if reluctantly the reality of elements. Accordingly, they talked of matter and even some kind of atomicity howsoever different from the *Vaiśeṣikas*.

In the second phase which fell into the period from AD 0 to AD 500 and when the Mahāyāna Buddhism was dominant, the Mādhyamika school under teachers like Nāgārjuna, Āryadeva and Bhavya advocated the metaphysics of *śūnyavāda*, which also meant that reality was absolutely independent and unrelated—अनपेक्षस्वभाव or सर्वधर्मशून्यता. In this metaphysics, the universe as a whole is admitted to be the ultimate reality, but it is itself motionless and inactive and in which neither origination nor dissolution is possible. Nāgārjuna's famous eight negatives or 'Nos' are: no interruption (*anīrodha*), no production (*anutpāda*), no cessation (*anuccheda*), no persistence (*aśāśvata*), no unity (*anekārtha*), no plurality (*anānārtha*), no arrival (*anāgama*), and no departure (*anirgama*). In the second phase, another active school, that of the *Yogācāra-vijñānavāda*, developed the concept of *ālaya-vijñāna*, the storehouse of consciousness, in which consciousness (*vijñāna*, *citta*) was recognized as the only absolute reality. According to this school, things are nothing but psychic representations; they are cognized in thought which, so to speak, only notifies them (*vijñaptimātratā*).

In the third phase, during AD 500–1000, Dignāga and his followers established the Buddhist school of logicians, which, with great logical sophistication and metaphysical flourish, veered round to the original Buddhist scepticism regarding the existence of an external world. Once again the permanent nature of matter was vehemently repudiated. Its *Vijñāna-mātravāda* held that all existence was mental and the ideas had no support in external reality (*nirālamba-vāda*). The original ideas of 'momentariness' and 'perpetual flux' were placed on a logical foundation to explain the illusion of the reality of matter. In his *Tattvasaṃgraha*, Śāntarakṣita has explained the doctrine as follows:

तथाहि सन्तो ये नाम ते सर्वे क्षणभङ्गिनः ।

तद्यथा संस्कृता भावास्तथासिद्धा अनन्तरम् ॥

सन्तस्वामी त्वयोष्यन्ते व्योमकाळेश्वरादयः ।

क्षणिकत्वं वियोगे तु न सत्तैषां प्रसज्यते ॥

क्रमेण युगपच्चापि यस्मादर्थक्रिया कृता ।

न भवन्ति स्थिरा भावा निःसत्त्वास्ते नतो मताः ॥

TS. 392–394.

'For instance, whatever things are existent are all in a state of perpetual flux—just as all created things have just been shown to be; these things, *ākāśa*, time, god and the rest are held by you to be existent—these could never have an existence if they were devoid of *momentariness*, either succes-

sively or simultaneously—therefore they are held to be non-existent.’ (Eng. trans. G.N. Jha).

The main argument, following Kamalaśīla, is: That which is existent must be momentary—यत् सत् तत् सर्वक्षणिकम् । The characteristic of existence is a capacity for fruitful action—अर्थक्रिया-सामर्थ्यम् । This capacity or potency for fruitful action is associated with momentariness only. What is devoid of momentariness is devoid of this capacity and is therefore non-existent—अर्थक्रियासामर्थ्यलक्षण-मिह सत्त्वं हेतुत्वनेष्टं तच्च क्षणिकत्वनिवृत्तौ निवर्तते ।

The same powerful logical apparatus which the Buddhists developed and perfected to refute the orthodox reality of matter and the physical world of experience were adopted by the *Nyāya-Vaiśeṣika* and other realist schools to controvert the Buddhist views. In the process the orthodox philosophies flourished and attained new strength and height. The part played by Buddhism in developing as a world religion, in stimulating art and architecture, in providing solace and peace of mind to large sections of humanity is undisputed. Its role in transmitting Brāhmaṇic astronomy, medicine and various other branches of science along with its missionary activity in Central Asia, China, Tibet, South-East Asian countries, and in West Asia in the early Caliphate has been widely recognized. But did it not fail to play a positive role in the advancement of sciences? This is a question which requires careful consideration.

The Vedānta philosophy, particularly the Advaita school of Śaṅkara, is marked by the theory of illusion (*māyā*). The origin of the theory of *māyā* is traced to Gauḍapāda who, in his *Kārikā*, put forward the idea that the world should be regarded as a dream and magic. The meaning of it is that all existence is unreal, that which neither exists in the beginning nor in the end cannot be said to exist in the present. Things are imagined as if existing outside, but they are illusory creations of the self (आदावन्ते च यन्नास्ति वर्तमानेऽपि तत्तथा । . . . तस्मादाद्यन्तवत्त्वेन मिथ्येव खलु ते स्मृताः ।। *Gauḍapāda-kārikā*, II, 6–7). Śaṅkara a pupil of Gauḍapāda and a great scholar presented the theory of illusion in such a way that it would not compromise his deep anti-Buddhist posture. Discerning critics, however, were not so easily decided and the Advaita Vedāntists were labelled as *pracchanna Bauddhas*. For the same reason, the positive contribution of this philosophy appears to be questionable.

SCIENCE, TECHNOLOGY AND SOCIAL CHANGE

I would like to conclude this essay with a few observations on the role of science and technology, along with other cultural, legal, and religious

concepts, in bringing about social change. In the days when the doxological history was fashionable, the activities of kings, emperors, courtiers, noblemen, court affairs and the like were the main materials of history. From around the beginning of the nineteenth century when the importance of the society and civilization came to be realized the emphasis shifted from doxology to the endless activities of man, his institutions, beliefs, ideas, sources of inspiration and the like, which contained the germs of true social change. This is evident from the writings of Sismondi, Augustin Thierry and Michelet on medieval town and country, of Macaulay and Grote on the history of political liberty, of Hippolyte Taine and Thomas Henry Buckle who, under the spell of Comte and Spencer, produced societal histories with proper emphasis on the role of ideas and ideologies. To this class belong Voltaire's *Siecle de Louis XIV*, Fustel de Coulange's *La Cite Antique* and Samuel Dill's *Roman Society from Nero to Marcus Aurelius*.³²

At one time the German historical school favoured the linear and sequential concepts of social development. For example, the village economy represented early feudalism of the eighth and ninth centuries; this led to the commercial economy centred round towns in medieval times; this was inevitably succeeded by national economy on the foundation of national states. Abbott Payson Usher, from his experience as a historian of technology, suggested that social change being far from linear is marked by several discontinuities, by many systems of events often working independently.³³ Failure to recognize these discontinuities, he warns, may make it difficult, if not impossible, to understand the development of processes important for the emergence of new structures and forms. Furthermore, in any society at any given time or period (if such a period can be defined) there are in operation several ideas, material agents and patterns of behaviour. Some of these ideas or events may be obsolete, some may be current and some may be nascent. For social analysis, it is important to recognize such obsolete, current and nascent ideas, concepts and events and understand their organic relationship.

To take a concrete example from Usher on the European situation during six hundred years from 300 BC to AD 300, this period was characterized by all the three categories of concepts. The obsolete systems were represented by various polytheistic religions, Roman law still lingering. The currently important concepts were those embodied in the Praetorian Edict which became the dominant element in Roman jurisprudence, the Euclidean geometry and the geocentric theory of the universe. The nascent concepts include a number of monotheistic religions and religious practices which assumed importance from first and third centuries AD, the heliocentric

	OBSOLESCE						CURRENTLY IMPORTANT							NASCENT					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
300 BC																			
200 BC																			
100 BC																			
AD 1																			
AD 100																			
AD 200																			
AD 300																			

Fig. 1. systems of events: 1-4 concepts, practices of various polytheistic systems; 5-6 archaic features of Roman civil law; 10-11 basic concepts of Euclidean geometry; 12-13 primary features of geocentric concept of universe; 14-16 concepts and practices of monotheistic religions; 17 heliocentric concept of planetary systems; 18 atomistic concepts in science; 19 invention and diffusion of water wheels. (*Based on Usher*).

concept in the germinal stage, the atomic theory and a number of mechanical inventions such as the water wheel. Most of these concepts in the three categories were discontinuous in nature in the sense that the Praetorian Edict did not arise from the Laws of Twelve Tablets, the heliocentric cosmology did not arise either from Euclidean geometry or from the geocentric concept of planetary movements. All these concepts organically interacted with one another to produce the broad European culture of the period. Similar elements are present in Indian societies, ancient, medieval or modern, which may, with advantage, be carefully identified and analyzed for a better understanding of the culture of the period.

Although science and technology represent two different areas of the same spectrum, technology is directly related to social change. The eco-

conomic role of technology has long been recognized. With regard to transport technology, Holmstrom calculated that human porters can move 1750 tons of goods per route mile per year per man, light pack animals 1590 tons, heavy pack animals 3600 tons, a bullock wagon 8640 tons, a horse-drawn wagon 15,000 tons, and an average barges operating with a tow in a natural water path can move 495,000 tons of freight per route mile per year on an assumption of 220 days of navigation in a year.³⁴ The railways increased this capacity severalfold and profoundly transformed the economic life wherever their networks were established. Similarly technology has been responsible for developing and understanding the potentiality of resources. Thus it is not enough to locate deposits of minerals like gold, silver, tin, copper, iron, coal, oil and so on. To appreciate their full potentiality in the development of the economy, technological process for geological and geophysical prospecting for correct evaluation of the total reserves, various mining operational techniques, beneficiation of ores, smelting, drilling, refining etc., are indispensable. All this calls for scientific knowledge at one end of the spectrum and the development of innovative technology at the other. Development of such scientific knowledge and innovative technology depends on ideas, material agents and behaviour patterns constituting the culture of a people in any given space and time.

Innovation or, in other words, the novelty of thought and action is vitally important for social change. Here lies the true significance of the third category of nascent ideas and concepts in a society. A society always functions with a set of concepts, ideas and practices which were once relevant but have now lost their relevance and with currently important concepts, ideas and practices. But whether it will tend to be dynamic or stagnant is likely to be determined by the presence or absence of nascent ideas and concepts. Which means that a society to be progressive must produce a group of people who are not only conversant with current modes of thought, techniques and processes, but who are aware of their limitations and shortcomings and capable of improving upon known knowledge and processes through innovation.

Two theories are generally advocated on the question of innovation, e.g., the transcendentalist theory and the theory of Gestalt psychology. According to the former, truth including new ideas is revealed in persons of genius from within by the grace of God. Descartes believed that scientific truth is revealed in this way. Clearly enough, the transcendental approach is not amenable to historical analysis. In Gestalt psychology, invention is the result of a cumulative synthesis of a large number of individual items in which many persons are involved and is therefore a social process.³⁵ In the transenden-

talist approach, each invention is considered to be an unrelated individual event, a rare phenomenon involving the participation of a rare genius. In actual situation, an invention arises out of a felt necessity after a long period of gestation during which many individuals exercise their insights at varying levels of perception finally leading to a cumulative synthesis sometimes by one bright individual and sometimes simultaneously by more than one. Francis Bacon had such an approach in mind when he proposed the organization of research in Solomon's House in *The New Atlantis*. Farrington writes: 'He looked upon the history of philosophy as consisting of a series of individual displays of brilliant intellectual powers which had achieved little or nothing for the relief of man's estate or the true understanding of nature. For this he proposed to substitute a quite different activity, the taking of a vast inventory of natural phenomenon by the organized teamwork of many men.' Furthermore, as the organization of research in Solomon's House in *The New Atlantis* makes clear, scientific work calls for various lower grades of intelligence also.³⁶ We know Bacon's ideas led to the foundation of the Royal Society of London and other science academies on the continent. Although brilliant individuals continued to make important contributions, organized scientific and industrial research worked wonders first in France under Napoleonic dispensation and later on in German university-cum-industrial complexes throughout the nineteenth century.

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$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34} \text{ (approx.)}$$

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Prolegom'ena Towards Any Future Study of the History of Cultures and Civilizations*

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The history of any culture or civilization is the history of man himself. As the understanding of man is difficult, both in its temporality and immediacy, the understanding of the history of what he collectively creates is also difficult to understand or articulate. The view of history will thus depend, on the one hand, on the view that we have of man, and on the other, on the idea one would entertain about time. However, as man himself cannot be understood in terms of any one of the dimensions he displays, so also we cannot understand the history of any culture or civilization in terms of the primacy of only one dimension in which it is found to have developed till now.

The problem of inter-relationship between different dimensions, facets, or aspects in which we try to understand man and his creations is fraught with even more difficulties than the understanding of one dimension or aspect. The problem is further complicated by the interrelationship conceived in either a linear or circular manner. Or we may even conceive of the relationship in structural terms where each is related to all the others simultaneously in a manner that contributes to the building of the whole as being conceived or apprehended in different ways. Beyond all this, there is the deeper problem of apprehending the lived feel of a culture or civilization and the forms in which it embodies itself. To the external observer, the primary thing is that in which the lived consciousness has embodied itself,

*This is part of a larger meditative reflection on the study of civilizations undertaken by the author when engaged in the diverse dimensions of the Project of the History of Indian Science, Philosophy and Culture.

while for the living person or persons what was perhaps most important was the way it was existentially lived through and experienced. However, the successive embodiments in which the living consciousness articulated itself provide a clue not only to the meaning or to the value or the purpose which is evidenced in them and through them, but, along with this and through it, to the seeking which is expressed through the successive evidences of that in which it has embodied itself. There is, thus, a visible and invisible history to be captured and articulated at both these levels.

A culture or civilization is not a natural entity. It cannot maintain or reproduce or modify and grow, as most natural processes, including those found in living beings, do. They have to be continuously preserved, maintained and passed on to successive generations in order that they may survive and not die out through forgetfulness or loss of knowledge regarding what they meant and how they could be reproduced. The undeciphered languages of the past are perhaps the clearest indication of this, but beyond these lies the obvious fact that unless something is taught and passed on to the next generation, it will soon vanish as a cultural or civilisational fact. The first thing one has to look for in the history of any culture or civilization is, what may be called, its techniques of maintenance and transmission. The technologies of maintenance and transmission of culture are to be first studied and understood. The second is that this process of maintenance and transmission is symbolic in character and is concerned with the understanding and interpretation of the symbols in which it is embodied. A symbol is primarily the relation of what may be a natural object to the consciousness about what it represents. The deepest understanding of any culture or civilization relates to the role of consciousness in the maintenance, reproduction and transmission of the symbols generated by it for conveying what it considers worthwhile and important to other consciousnesses so that these may be transformed and tempered by an encounter with the understanding of what the symbol is supposed to represent or refer to.

A cultural fact therefore presents a double challenge to the consciousness that encounters it. The first is its recognition as a cultural fact, that is, as a product of some consciousness and hence as conveying a message different from what it would have conveyed if it were treated as purely an object of nature. A natural object is also embedded in a causal nexus and hence can always provide information about the past of which it is the result. But the past of a cultural object is radically different from the past which may also be constructed or read or inferred from any natural object when we see it as the result of a process which has produced it. The cultural object does not lie in a causal nexus alone but gets meaning either through the

purpose for which it was created and/or the meaning which it was supposed to embody. However, as the cultural object is also a natural object, though every natural object is not a cultural object, it simultaneously displays these two different dimensions at the crossroads of which it exists. It has to be understood simultaneously in terms of the causal processes which it presupposes and the purpose for which it was created and the meaning which it embodies.

The causal, the teleological and the valuational dimensions thus intersect in it and it demands an interpretation in all these dimensions simultaneously. Furthermore, as a cultural object does not exist in isolation but only in relation to other cultural objects which display the same characteristics, it has a structural and interrelational component which radically modifies its understanding from the one which occurs when it is seen in its own terms and in isolation from others. The causal understanding is a function of the causal information that we possess and hence the same cultural object in its natural aspect will provide different information as our causal understanding about nature changes over a period of time. The purpose and meaning, on the other hand, are a matter of postulation and divination which are basically a projection of the way we understand our own purposes and meanings and the life that the interpreter lives and observes around him in the living present. However, while the causal knowledge is fairly objective and uniform at a given moment of time, at least among those who are supposed to be knowledgeable in the field, the apprehension of purposes and meaning is neither so objective nor uniform and varies from interpreter to interpreter in a far more radical sense than the former.

There is, in fact, yet another problem with respect to the teleological and the valuational dimensions of a cultural object and their understanding by an interpreter in terms of his own knowledge of these in his own experience. Normally one not only always gives a benefit of doubt to oneself and denies it to others but almost always tends to interpret one's own purposes and meanings more nobly than those of others. The valuational hierarchy that is intrinsically in-built around purposes, meanings and values always creates a dilemma as how to interpret a cultural object, for it can always be interpreted in terms of purposes that are low, mean and selfish or their opposites. The structural relationship of a cultural object to other such objects tends to remedy this tendency to some extent but perhaps the solution may lie in interpreting cultural objects simultaneously in both ways and by the alert awareness regarding one's own tendencies towards interpreting one way rather than another.

The chronological dimension of succession where something precedes

and something else succeeds in a sequence gives rise to a problem of a different kind than the one discussed above. The latter may either be seen as necessarily an improvement of the earlier or as a decline and degeneration from it or as sometimes the one and, at other times, the other. The linear succession gives rise to one of the strangest illusions in the writing of history. It continuously distances the past from the present and makes us feel that we are moving towards something in the future. However, as the historian is not much concerned with action in the present to bring about the future, he sees the past as receding from himself and thus he sees all that is in the past as either nearer to him or farther from him. His is the determining location which determines the 'pastness' of the past. Conversely, he sees the whole past as *leading* to the present in which he is situated and thus he builds a sequence where each event is seen and understood not in terms of itself or even in relation to others with which it may be said to be co-present, but rather in terms of that from which it has arisen and that which it gives rise to. Generally, it is the second perspective which prevails and the past is significant and meaningful only to the extent that it is seen as giving rise to the present.

The present, however, in which the historian is situated, is not a uniform present for all the historians who may be said to be contemporaneous to one another. Divided as they are by the societies, cultures and politics in which they happen to be situated, and of which they are active members and with which they identify themselves, this cannot but shape the perspective which they have on the past as it will be seen in terms of their own present rather than that of someone else who also is situated in the same time which though chronologically simultaneous, is culturally and politically different from those of others. Moreover, as the past of these presently located societies, cultures and politics is not monastic or isolated in nature, their own interrelationships with the present and the past tend to make a substantive difference to the way the past itself is perceived and constructed.

The problem of understanding other cultures has been discussed in social and cultural anthropology and many of the difficulties in understanding the 'other' have been articulated and discussed. But the similarity of the problem with respect to the understanding of its past by a present civilization or culture has not been noticed. The historian's dilemma is perhaps the same as that of the cultural anthropologist, except that he is not observing or trying to understand something that is alive and functioning before him but rather trying to reconstruct on the basis of evidence left behind. The difference is between reconstructing a past life on the basis of available evidence and delineating the present life as it is being lived.

The problem of linear temporality in which all history is embedded and which provides the scaffolding for all historical construction, as usually discussed, forgets that the linearity of time is itself a function of shorter and longer cyclical time-processes. We all know that a day, which is measured in twenty-four hours, is the time taken by the earth to complete its journey around the sun. Even at the socio-cultural level, we repetitively perform the same actions and have the same cycle of seasons and festivals and through these try to achieve something which is non-cyclical and linear. The cycles, of course, can be shorter or longer and, like the movement of a wheel on which the chariot or the carriage moves, results in the movement of something else in a linear fashion. At a deeper level, the distinction between linearity and sphericity may be said to lessen as the sphere becomes larger and larger in size. There is the well-known problem with respect to space as to whether it is spherical or linear in character. But, as is well known, the larger the radius of the circle, the lesser the curvature of the circumference and for short distances, it almost approximates a straight line. That is of course one reason why it is only at very large astronomical distances that the question arises as to whether space is essentially Euclidean or non-Euclidean in character. The interesting point, however, is that normally the historian does not see the interaction between the linear and the cyclical in his view of the past, but rather sees it primarily as a case of linear succession alone.

There are of course exceptions, and Toynbee is perhaps the most famous example amongst them. But he was too much obsessed by the rise and fall of civilizations and treating this as the paradigm of the cyclical element in history, while progress in religion for him was what this cyclical movement produced in terms of linear progression. Even here he was hampered by his own rootedness in Christianity and preference for it. If he had been true to his own insight, he would have seen that the cyclical movement of history, in terms of the rise and fall of civilizations, would make humanity progressively realize higher and higher religions in an unending temporal manner. There is perhaps a hidden insight in what Toynbee was trying to do; but the insight, if any, would have to be disentangled from both the paradigm of cyclicity that he chose, i.e., the rise and fall of civilizations and the centrality of religion which he considered as the exemplar of that which the cyclical movement of history progressively realises.

The most fundamental cycle on which all other cycles are based is the life cycle which man shares with all living beings. However, the first task of every culture has been to transform this cycle, rooted in biology, into a cultural cycle and that is why in all cultures birth and death are not just

biological phenomena but profound cultural events associated with a lot of ritual and ceremonies which transform the biological into the cultural. This is also the reason why marriage ceremonies hold such a pivotal role in all cultures. The very idea of setting up a household is itself a cultural phenomenon entailing all the duties and responsibilities of a householder towards not only the elders in the family, i.e., parents and other elderly relatives, but also to other members of the kinship group and to other members of the society.

In the Indian context, the responsibility of the householder extends even to those who have formally renounced all society, that is, the mendicant and also to those who have not yet entered the social realm formally, i.e., the *brahmacārins* or the student community and, interestingly, both the *sanyāsī*, including the *bhikṣus* belonging to the Buddhist and the Jain traditions, and the students usually known as *brahmacārins* had a right to seek alms from the householder and it was supposed to be his duty to support them by responding positively to their request for being given the alms to which they were entitled, even though the former had renounced society and the other had not yet entered it. '*Bhavati bhikṣām dehi*' was the identical formula used by both in this connection. It may be noted that it was the woman of the household who was asked for alms and that there was no privileged position for one's own children from those of others. In fact as all children were supposed to reside with some or other teacher and were all supposed to ask for food from the householders in the vicinity, one's own child was as demanding for the right to be given food from some household as the children of others from one's own household.

However, in the context of cultural continuity the basic cycle is not the biological one, but something imposed on it. And thus the biological cycle itself becomes the basis of what may be called the fundamental cultural cycle on which all other cycles are based. The biological cycle itself has two distinctive aspects, which though interrelated, lead to different directions. The individual cycle from birth to death is intimately entwined with what may be called the reproductive cycle, i.e., bringing a human being into existence with the cooperation of the opposite sex. The individual life cycle thus is completely intermixed with persons in the family for bringing into being children and rearing them over a long period of time. The human child is perhaps the most helpless of all living beings at the moment of birth and requires a long time for his growth and maturity. The biological cycle of the individual is therefore necessarily enmeshed not only with the biological cycle of another human being of the opposite sex but also with the growth and development of the children for whom one is responsible. Conversely,

the life cycle of the children inevitably develops in relation to that of their parents and of their siblings along with those of their own age group in the neighbourhood and the elders who surround them. Family is thus the basic unit in which the diverse biological cycles are co-present in an inter-active manner giving rise to its basic character as the cultural unit on which, and through which, most other cultural cycles are imposed.

In fact, the beginning of the cultural cycle may be seen either from the beginning of the birth of the human being or even from the moment of conception or from the marriage of two individuals who jointly give birth to someone. It may be interesting to note in this context that the Indian social scientist dealing with the essential issue of socialization and acculturation starts with the central fact of marriage as the cultural pivot on which everything revolves and treats the processes leading to the birth and development of a child on the path of biological and cultural maturity as subservient and consequent to it in the cultural context.

The transformation of the biological into the cultural is done through the superimposition of a ritual that is specific to each crucial occasion in the cycle of the biological process and the invocation of the sacred and the transcendent which infuses a transnatural dimension into a natural phenomenon and thus gives it a different character from that seen by the natural, objective, behaviouristic eye only. The ritual has two purposes: to superimpose a non-natural causality on a causal nexus which is natural in character and to give the whole thing a symbolic character which makes its meaning significant which no natural process can possess if it is seen in its own terms only. Beyond these two essential functions of all rituals, there is a third one of relating the symbolic character of the transformation to the world of the transcendent which itself may be conceived of in diverse ways. The distinction between the 'sacred' and the 'transcendent' on the one hand, and between the 'sacred' and the 'significant', on the other is necessary, as meaning and significance need not consist of the sacred and the transcendent only.

One of the interesting consequences of this distinction between the meaningful and the significant dimension of ritual from that of the sacred and the transcendent might be to explore the shift in the function of ritual from the one aspect to the other in the history of cultures and civilizations. The other, and equally important characterization of cultures may be sought in the types of the sacred and the transcendent which the ritual primarily indicates in a particular culture and the shift over a period of time from one form of it to the other. The changes in the forms in which the sacred and the transcendent are conceived are as important as the changes in what is

regarded as meaningful and significant. Furthermore, as rituals have always an aesthetic aspect to them, the changes in aesthetic taste and sensibility are also reflected in changes in the form of the ritual that take place in a society over a period of time.

There is another aspect to the performance of ritual which generally has not been taken into account. This is its relationship to the sense of temporality and the attitude to time which itself changes over time in the history of civilizations. In fact, if space and time are the fundamental forms of sensibility, as Kant thought, the attitudes to space and time and the forms of their sacralization would be one of the most important clues to the understanding of the changes taking place in a society over a period of time. Time, in Kant, is the form of inner sensibility and thus, indirectly, is the form of everything else. The idea of sacralization of time, then, to a certain extent would involve the sacralization of consciousness also.

One may, of course, not accept Kant's formulation of the problem but the question of the basic attitudes to space and time and their transformation through ritual activities, along with their relation to consciousness, remains central to all investigation of human societies, cultures and civilizations. It might be interesting to develop a typology of attitudes to space and time and characterize cultures and civilizations in terms of them and see the changes occurring in them over a period of time by any and every evidence which could possibly be related to them. Everything has a spatial organization about it, that is, it is not only located in space but structured in spatial terms also. Temporality, of course, is not visible in the evidence left behind by cultures except in terms of sequences and layers in which archaeological data are found. But wherever literary records exist, they may be viewed not only in terms of their treatment of time within the texts themselves but also in terms of the immanent time-frame of the texts themselves. Even such things as paintings may reveal an internal time sense in the way they are organized. Scrolls, for example, which have to be unrolled vertically reveal a different time sense from those which have to be unrolled horizontally. Similarly, the different sequence of events given in different parts of the same painting reveal a time sense which is different from the one in which they are shown successively. The organization of space in a painting may also offer clues to the way space was apprehended and responded to in a culture. Architecture is perhaps the most classic example of an art form in which space and time are simultaneously blended. The latter is there in an invisible form as it is related to the movement that a person is supposed to perform to apprehend a complex architectural form.

Time becomes more evident in such art forms as dance, drama and music as also in the way the epics are written and other texts composed.

The theme is too vast and we are not interested in explaining it in depth here. What is important however is to become aware that any writing of history, which ignores the changing sensibility to space and time and their relation to ritual on the one hand and leisure on the other ignores the most fundamental fact of biological, social and cultural living. The biological rhythms themselves have a cyclical temporality and a spatiality which is related to the human body as a central measure in terms of which everything else is seen. The distinctions of the right and the left, of above and below are the distinctions of the human body and so are distinctions of the large and the small. Similar are the rhythms not only of waking and sleeping, but also of attention, its span and intensity and at a still deeper level of the psychic cycle of outward movement and inward withdrawal along with rhythms of enthusiasm and alienation.

The spirit and movement of a civilization in space which necessarily involves time in a certain sense and its being affected by this expansion into regions which have their own geographical and climatological peculiarities along with the peoples and the cultures it encounters in its outward movement and the changes these bring about in it have seldom been subjects of intensive attention by historians, particularly in the context of its purely spatial considerations. On the other hand, the temporal movement inevitably introduced by the cycle of generations and processes of cultural transmission over generations, and the inevitable modifications that are introduced in the transmission process have been the subject of some attention but not in the context of temporality itself. The intertwining of biological temporality with cultural temporality on the one hand and geographical space with cultural space on the other provide an interaction between two different realms whose understanding requires cognitive discourses of different kinds. The expansive spread of a civilization, over space, itself introduces changes and modifications, which are different from those that inevitably occur through the temporal dimension of the transmission of a culture over generations. The latter would occur even if there were to be no expansion or spread of the outward movement into space, while the former would not take place without such an occurrence.

There is of course another dimension to the outward movement of a civilization as its carriers ultimately are human beings who chose or are forced by circumstances to move outside or beyond the settled frontiers of their original habitat. These persons may usually be regarded as more

enterprising, innovative and daring than those who prefer to stay in the familiar environment and the settled life in which they are located and accustomed to. One may therefore expect that the outward movement of a civilization is also accompanied by changes and innovation not only because the persons who move beyond the settled frontiers are adventurous, daring and innovative but also because they are less inhibited and constrained by their cultural environment.

There is, of course, the problem of the frontier which itself is generally nebulous and arbitrary. Beyond the frontier, there may be other cultures and civilizations.

THE OBSERVER AND CHRONICLER OF EVENTS

The former normally occurs when other cultures and civilizations arise and force the earlier culture or civilization to recede in spatial terms to its former niche. It can take many forms and has many interesting variants which we will explore a little later. The receding of a culture into its inner shell is however a more interesting phenomenon as it is not only not generally noticed but also because it is the defensive response of a culture to maintain its identity under adverse circumstances. This normally takes place when an alien people politically conquer and rule a civilization with a long history of its own and an identity deeply rooted in the psyche of the people. The culture withdraws into its shell and tries to preserve what it can in such circumstances. The historian interested in only political events misses the significance of these responses and fails to understand what the protagonists of the culture are really trying to do under an alien political domination. The history of India is perhaps a classic example of such a situation. Being a civilization which for millennia had explored its own *puruṣārthas* in various fields, it has had the singular situation of being under the political domination of alien rulers in different parts for long periods of time. The successive responses and strategies adopted by the carriers of the civilization in such circumstances have neither been understood nor articulated by most historians who have written until now the history of this long enduring culture and civilization.

Perhaps one of the most interesting phenomena which the Indian civilization has experienced in the context of political domination by an alien people is that the domination has seldom, perhaps never, covered the whole of the geographical and cultural area which is formed by the natural frontiers of this civilization. Even the British, who after 1857 are supposed to have ruled the whole of India and unified it under a single political and adminis-

trative system, left large parts of the country governed internally by the different states with which they had entered into all sorts of treaties. These states, though politically under the suzerainty of the British, were fairly autonomous in the way they carried on the internal affairs in their various states. A comparative study of the way the different states functioned, particularly with respect to the task of carrying on a large and varied cultural tradition of India both in terms of its maintenance and development has yet to be studied. The important point, however, in this context is that at no time in its long history the political rule of an alien people extended to the whole of the sub-continent and some regions were always outside the centres of political power which have fascinated the historians, particularly during the last one thousand years of India's history.

The external expansion of a culture or civilization may be stopped or cut short in different ways. It may lose the momentum or it may meet resistance to its spread from cultures other than its own. But in all cases there is the problem of preserving the identity or a continuity with what one had started from. Those who move forward look back and remember what they had departed from, while those who stayed behind remember the situation very differently. In a sense it is a question of diverse forms of cultural memory which shapes cultural identity and its continuity. How does a culture preserve this memory and through what processes does it renew its identity that with which is not only long past but is also separated by vast spaces? The situation becomes even more complex when one is cut off from the peoples belonging to one's own culture by natural obstacles, such as, the oceans or the mountains, or by intervening spaces occupied by cultures of a different kind. All migrant populations which live in far off islands, continents or places have this problem and they respond to it in a way which is very different from those who continue to occupy the same space in which the civilization was born and flourished for a long time.

The intersection of the past and the future as well as that of the here and the beyond provides thus a matrix within which the history of any civilization or culture may be apprehended. All past evidence therefore has to be interpreted as if it existed at a confluence of the perspectives occupied by its creators in terms of their own 'past' and 'future' and their own 'here', and 'beyond' in the ways they apprehended it.

The point is that while to the historian everything is past, it was not so to those who were living in those times and left the record on the basis of which we try to articulate and reconstruct the so-called past. Similarly, the so-called spatial location of the creators of the evidence, though located at a particular place, was not just that as they always related it to something

beyond which was an active component in their consciousness. The horizons of space and time have to be seen as necessary inbuilt ingredients to all evidence which a historian uses for the construction of history.

But what is this construction? What is this act which a historian performs consciously or unconsciously all the time? Are there any transcendental *a priori* forms of this construction? Or, if one does not prefer the Kantian terminology, are there any necessary conditions which cognitive construction of the past has to fulfil? Or, are there always alternative histories and the building of one, an act of choice itself determined by considerations which may not be cognitive in nature?

Yet, whatever be the factors determining the choice that a historian may make, or that the writing of history itself may necessarily involve, there are some *a priori* conditions which any historical construction has to fulfil and unless we become aware of them we would not see the formal constraints that the historical enterprise itself involves. The point is that even if one grants that there are, and inevitably must be, alternative historical constructions from the same data, even then, a certain commonality has to be granted in order that the alternative pictures or constructions may be regarded as 'pictures' or 'constructions'. The first and foremost condition that any historical writing has to fulfil is that it has to be a dramatic narrative which unfolds in a process of time, where there are protagonists who are in conflict and whose actions are determined by motives easily intelligible in terms of common human experience leading to consequences which they themselves cannot foretell. The closest genre to the writing of history, therefore, will be the novel or the drama, except for the requirement that there has to be independent and verifiable evidence both for the characters who are part of the story or the play and of the actions which they are supposed to have performed as well as the consequences that followed from these actions or lack of action. Besides this the historian, unlike the novelist or the dramatist, is bound by the objective locations of space and time in which the events he is describing have unfolded. He cannot choose the place and the time, or the characters, or the evidence or the consequences. These are given to him and he has to build a credible story out of it. It may then be asked as to what is the difference between a historical novel or a historical play and a piece of writing which is formally designated as history. The only difference which the two designations imply is that certain questions cannot be asked from the one which can relevantly be asked in response to the other. Anything that is designated as historical novel or a historical play need not be necessarily true in respect of the 'facts' it

describes, while, in the case of any writing which claims to be history, these questions can always be asked relevantly, and in case they are answered in the negative, it loses its claim to be a legitimate history. The historical imagination, therefore, has a function totally different from imagination exercised in the field of literary arts even when they claim to be historical in nature.

It might be interesting to compare the writing of history, say, to the painting of a landscape or the painting of a portrait where imagination and truthfulness to what is observed go hand in hand and create the possibility of diverse creations about the same thing. Painting however has a constraint of its own, i.e., the organisation of pictorial space and the creation of three dimensional effects on a two dimensional surface and, also the relations between colours and the way they interact and modify each other. One is not quite sure if there are any analogues to these types of constraints in literary writing where it is the words alone that possibly perform the analogous function.

There is of course always the problem as to how historical writing achieves its effect. Is it the skill and the style of the writing that produces conviction in the reader of the historical truth, an impression that may have little to do with the truth of the evidence on which the writing claims itself to be based? Recently this issue has been raised by Clifford Geertz regarding the writings of eminent anthropologists and he has argued that the authority of the great anthropologists derives not so much from the factual basis of their interpretation of the culture is based but rather by the style of their writing, so much so that even when it is known that the so-called facts on the basis of which the pictures of those cultures were created are untrue, the picture continues to be authentic.

The difference between cultural anthropology and history lies in the fact that while the anthropologist claims to be an eye witness and a participant observer in the society and culture he is objectively describing, a historian, by definition, is neither an eye witness nor a participant observer of anything he describes as history. He reconstructs events relying on eye witness accounts of others and documents left by those who were actively involved in the events themselves. He is thus, a second hand or a second level anthropologist generally studying cultures which themselves are literate and record their own events and activities. However, both have to present a convincing coherent picture that has to give a lived feeling of objectivity and truth; and in this, the style of presentation is as important as the multifarious evidence on which it is based. Just as *The Golden Bough* of Fraser is not an

ideal anthropological work in spite of the wealth of detail that it gives, similarly the material collected in the archives of the world are not history but only the raw material out of which history is created.

The great historians like Gibbon, Mommsen or Trevelyan are, therefore, as much distinguished by the style of their writing and the vision that informs their work as the anthropologists whom Geertz discusses. In fact, it is not the cold facts documented in abundance and referred to in the footnotes or in the appendices that makes the classic work of a Marx or a Hegel important as history, but the passion and the drama which pulsates through every page of what they have written. For Marx, it is the rage against injustice and exploitation and the vision of a society and polity free from all exploitation which provides the structure for his work just as for Hegel it is the concretization of the absolute spirit in time and its unfoldment through a dialectics of its own that gives the sustaining and living structure to the whole of his historical work. For Weber, who is not generally regarded as a historian, the impulse is the story of reason in a different sense than in Hegel. It is corporate rationality that ultimately manifests itself and the impersonal rationality of the bureaucrats and the interplay between charisma and the routinization of charisma that provides the life blood not only of his study of capitalism but also of his study of world religions.

The anthropologist, however, suffers from a limitation which the historian normally does not have. The former sees and describes a culture primarily in static terms, and this is so even when he or she tries to articulate it in terms of the values that are exhibited therein and which distinguish it from other cultures. By the very nature of his preoccupation, he cannot depict or describe societies or cultures as involved in an exploration of values and trying to realise and embody them to the extent they are capable of. There is a snapshot picture of a culture even when it is a video snapshot or even a video film. The historian may also impose this limitation on himself, or succumb to it unconsciously if he confines himself to a period or a particular space-time region which he tries to 'understand' through the documents and the evidence left behind.

The dialectical relationship between a value apprehension and a value realisation has seldom been the subject of either philosophical or historical investigation. Normally, a value when actualized or realized does not seem to be the same as when it was apprehended imaginatively or intuitively; rather it shows deficiencies which one had never imagined to be there. Justice for example, or equality, or liberty, when actualized reveal grave deficiencies which again demand to be remedied by a more collective effort

on the part of individuals which at least is partially determined by a more sophisticated and differentiated apprehension of the same value than the way it was grasped earlier. Hegel had called the earlier apprehension as abstract and the later as concrete, but in this he was deeply mistaken, for it is the abstract which provides the ground for the criticism of the concrete from an evaluative perspective. But, though profoundly mistaken, he had the insight that unless one tries to actualize a value, one will not know the limitations of one's own apprehension. Hegel's mistake only was that he seemed to have thought that the limitation lay in the abstractness of the value apprehended and not in the apprehending act itself. The continuous interaction between the abstract apprehension and the concrete realisation provides one of the ways in which history may be said to overcome the limitation of anthropological description, as it sees societies and cultures in a changing temporal perspective and not as timeless activities reproducing themselves perennially by repeating the processes cyclically and indefinitely. In the historical perspective, it is the dissatisfaction with the present in terms of the abstract ideals that are apprehended which provides the basis for a dynamic change in the situation giving the temporal dimension of man, a meaning and significance, which it would otherwise lack.

This however would imply that human history has itself to be seen as a struggle for the realization of values and the difficulties encountered in their realization as well as the inadequacies and limitations revealed in their apprehension by the attempt at their actualization. The votaries of the abstract apprehension generally place the blame for the deficiencies of actualization either on human nature or on some other external circumstances which somehow distorted the actualization of the value. This is the usual plea made by all traditional upholders of the original valuational vision embedded in a foundational text or the sayings of a prophet. Both sacred and secular religions have had their defenders blame something else for the failures of the value realization and not the original valuational vision itself.

The history of the value apprehension and the value realization of man thus may be written in two forms. One, the successive attempts by the orthodox to continue to try to implement the logic of the original apprehension rigorously even if they find that the attempt at its realization is revealing increasing deficiencies and even positive negativities which they themselves regard as such. On the other hand, the history may take the form of a delineation of successive modifications in the value apprehension in the light of the negativities revealed in the course of its actualization and implementation. As a matter of historical fact, both tendencies have been present and

there has been sometimes a domination of the one or the other. There may also sometimes be an interaction between the two and the accommodation of one by the other.

Beyond this, however, is the story of a new value apprehension or the extension of an old value to new domains or the rising into dominance of a value which played only a marginal role in the culture or civilization whose history one is attempting to write. Moreover, as values are always in the plural and they are not always harmonious or complementary in their relationship, any history that is centred on what has been called *Puruṣārtha* in the Indian tradition would have to see their mutual relationships, both conflicting and complementary, in the history of that culture or civilization.

But, even if the drama about the valuational seeking of man is made central in the writing of history, it cannot be forgotten that for the actualization of values one needs both the knowledge of causality and the building of technology for effecting that causal knowledge. Thus technology and value apprehension are closely related to each other, for without technology one cannot attempt to actualize any value whatsoever. Thus *śilpa* and *puruṣārtha* are the key concept in terms of which any history ought to be written. The concept of *śilpa* or technology both presupposes some sort of a knowledge of causality and the transformation of that causal knowledge into an effective instrument for the utilization of that knowledge. Knowledge itself may be either at the level of a practised skill where one knows that if one does this and this, then, most likely, this would happen. Most of the practical skills are of this kind and whenever one wants to do anything, one depends on such skills which one has acquired over a period of time. The knowledge on which the skills are based or which itself is displayed and embodied in the skills may however be itself organised as a systematic body of self-conscious knowledge. There may be, what is usually called, a *Śāstra* or an organised body of knowledge.

The formation of a *sāstra* out of preceding skills in certain areas results in both an advantage and a disadvantage. The advantage obviously is that the knowledge is organised, codified and assumes a self-conscious form which is primarily intellectual in character and conceptual in nature. It also treats the so-called skill in terms of 'knowing' rather than 'doing'. It is thus the cognitive aspect that comes to be emphasized rather more than the performative aspect in which the skill was solely embodied earlier. This, however, gives it a fixity of a very different kind from the one that was there at the level of the skill which was continuously modified not only in the process of transmission and training but also because of the challenges which the changing situation exercised or imposed on it. The *sāstric* knowl-

edge also generated problems of its own which have little to do with the actual performance of the skill or the exercise of that knowledge. The intellectual problems generated by the *śāstric* formulation are almost always of a conceptual nature, concerned with what was really meant and whether what was being said was coherent or not and whether it was sufficiently justified in terms of the evidence and the argument given in support of it. It was always bedevilled by an increasing concern with the problems of meaning, justification and validation giving rise, on one side to *śāstras* or the sciences of linguistics, grammar and hermeneutics and, on the other to, what has been called the *pramāṇaśāstra* in the Indian tradition, or the sciences concerning logic, epistemology and philosophy of science, *vyākaraṇa*, *mīmāṃsā* and *nyāya* thus emerged as independent disciplines which became the foundation for the study of all *śāstras* as they deal with problems of meaning, interpretation and validation. The mind thus gets involved in problems of a different sort than those with which the exercise of a skill is concerned. The problem of coherence or validation or interpretation or meaning does not enter the realm of skills at all. The skills are either successful or unsuccessful in so far as they achieve their purpose or not. Skills, of course, are sometimes subservient to a larger purpose as in the arts where what one tries to achieve is something that transcends the skill. Normally, this is conveyed by the term 'beautiful' or 'significant' or 'meaningful' which tries to describe this extra element which supervenes on the exercise of the skill and which is supposed to be defeated or even negated by the exercise of the skill for its own sake. Sometimes the exercise of a skill for the sheer joy of it is akin to playfulness which is justified in terms of itself and not for the sake of anything else. But even playfulness has to have an aesthetic element in it in order to be satisfying and enjoyable at least to a discriminating beholder or a spectator. One may enjoy one's playfulness oneself, but whether others do it also is a different matter. One may, of course, arouse wonder or amazement by the exercise of the skill but whether they are also aesthetic in character is difficult to say. It will be interesting to ask as to what is the basic difference in these emotions when they form part of a feeling of sublimity and awe in respect to a great work of art and when they arise independently of these and give rise to a feeling simultaneously of admiration and revulsion at the fact that such a tremendous skill is being used just for gimmickry or the 'showing off' of oneself.

There is perhaps a radical distinction between those arts where skill is always expected to be subservient to an end beyond itself and where such a situation does not obtain. In many forms of crafts and gymnastics such a situation prevails as skill seems to be the only thing whose display is the

end of such activities. In fact even in the sphere of *śāstric* learning there is an exercise of intellectual skills of argumentation which many a time are exercised for their own sake. Argument for argument's sake is not supposed to be a bad thing in the field of *śāstric* learning, but even there one always prefers its exercise in the service of truth or enlightenment.

The basic point is that when skills in any field are grounded in the self-conscious formulation of a systematic body of knowledge known as *śāstra* or *śāstric*, then it gives rise to a relatively autonomous set of problems which begin to have a parallel life of their own. Thus the development of *śāstras* and the development of *śilpa* in a particular tradition become independent of each other, and though the two sometimes interact and influence each other, this happens only sporadically and accidentally. The developments in grammar and linguistics do not ensure the skill in using language nor does, for that matter, the developments what in India has been called the *Kāvya Śāstra* or the science of poetics, helps in creating great works of poetry or literature.

The relations between *śilpa* and *śāstra*, on the one hand, and both of these to *puruṣārthas*, on the other, should be a matter of investigation in order to make history humanly significant. On the other hand, it is equally necessary that one does not see it as a one-way movement where the *puruṣārthas* determine the *śilpa* and the *śilpa* gives rise to *śāstras* but the *śāstras* may themselves give rise to new *puruṣārthas*, or at least bring a radical transformation in our understanding of the *puruṣārtha* by making that possible whose very possibility could not have been conceived of before for the lack of adequate conceptualisation or technology to achieve it. Similarly, *śāstric* formulations not only bring the whole differentiated world of intellect and reason into existence but also provide a new *puruṣārtha* of intellectual or rational knowledge for man which is absent if they are not developed or only marginally developed in a culture. The development of new *puruṣārthas* in the history of a culture or civilization would perhaps be one of the more important ways of looking at man's history as it will emphasize ways of making his life significant in the pursuit of new ends of a different kind. The drama of human history is that of man's pursuit of diverse ends which he considers worth pursuing and which normally have been provided by the culture he has been born in. Thus the emergence of any new *puruṣārtha* on the horizon of human consciousness should be seen as a breakthrough in human history providing the possibility of a new kind of pursuit not available earlier. The difference between diverse civilizations may be viewed in terms of diversities in the dominant *puruṣārthas* which they pursued over a long period of time and which they explored in depth and articulated and em-

bodied in the products they left behind. A mapping of the *puruṣārthas* and their self-conscious formulation in a particular civilization is thus a prime desideratum for attempting any history of that civilization or culture. Yet, as one's own language seems to be the most natural for a human being born in the group in which it is naturally spoken, so also do the *puruṣārthas* as articulated in one's culture. It is only when one encounters a different formulation that one begins to apprehend the contingency and the parochiality of what one had unconsciously accepted as the only possible formulation of the ends worth pursuing and the means for their pursuit.

The triad of *śilpa*, *śāstra* and *puruṣārtha*, however, has to be supplemented by another dimension without which neither human beings nor their history may be understood as human history is only the history of man. One has to ask, how human history has differed from all non-human history, i.e., the history of living beings, and that of inanimate matter. The idea of evolution is not confined to human history alone. In fact the idea was first applied in the field of geology and later in the field of biology in the context of the origin of species. Only later on, it was transferred to the humanistic disciplines. But all living phenomena at non-human levels do not, and perhaps in principle cannot, display any distinction between the natural and the non-natural, and between the secular and the sacred. In contrast, all human phenomena try to distinguish themselves from the world of nature by imposing another aspect on it which they call cultural, and within the culture itself they distinguish between the sacred and the non-sacred. It should be understood that the non-sacred aspects of culture are not regarded by it as natural and that any of them can be sacralized by a prescribed ritual or even by a change in attitude towards it. The world of nature itself can be seen as sacred by an attitudinal change towards it. In fact, the distinction between the natural, the cultural and the sacred is ultimately rooted in the attitude that views an object or an event in these perspectives. However, the process of transforming something natural or something that is pre-given as an object to man into something cultural is very much akin to that which transforms the cultural into the sacred. In both cases a ritual element is involved along with a transformation of dominant meaning and the psychic attitude towards it. The world of nature, when it is seen and treated as primarily natural, is governed by mere causality or seen as pure happenings without any ulterior purpose or end in view. The world of non-human living beings, though embedded in inanimate nature, displays characteristics which cannot but be described in terms of quasi-purposes about which man can never be sure whether there is any genuine purposive activities involved in it, or it only appears to be so. In the case of human beings however, the

category of purpose remains quasi no more and seems to describe the distinguishing character of human action which *uses* the causal relationships which are found in nature, both at the level of inanimate matter and that of living beings, for his own distinctive goals of which he is self-consciously aware and which he can easily tell someone if asked about them.

The teleological transformation of the causal however is not the only thing that occurs at the human level. The purpose itself is transformed into the meaningful and the significant, dimensions which are totally absent at the level of non-human living reality. There is not even quasi-meaningfulness or quasi-significance displayed by non-human living beings in their behaviour, even though it seems at least quasi-purposive in character. This transformation of the purposive beyond the biological into the meaningful and the significant, which operates at all levels of human consciousness, is achieved by the process of symbolization and ritualization whose collective name in the Indian tradition is *saṃskāra*. The term *saṃskāra* of course has other meanings also, but its crucial meaning, particularly when it is used in its verb forms, refers to the procedures by which the natural is transformed into the cultural.

The process starts from the biological moment of conception to the whole life cycle which ends in the death of the individual. At each crucial moment what is biological or natural is not treated as just that but is imbued with a significance by taking up the event into a whole set of ceremonies which give it a meaning beyond the biological fact and is shared by all other living beings also. Birth is not merely birth and death is not merely death, though seen as natural events they cannot be considered as anything else. The whole *Samskāra Kāṇḍa* of the *Dharmakośa* which runs into six volumes is primarily concerned with the ceremonies performed at different stages and periods of one's life. It may normally be thought that the ritualistic cycle of the transformation of the natural into the cultural will start at the point of birth or at the point of conception of the human being but the *Dharmakośa* chooses to start not at the moment of birth or conception but rather with marriage as it is the ritualistic consecration of marriage that provides the occasion and the legitimization of the conception or the bringing into being of the human person who is not conceived of as merely a biological entity but something radically different from it. The whole notion of marriage lies thus at the centrality of transformation of the natural into the cultural through a ritual that makes something biological into a cultural phenomenon.

We have, therefore, to add *saṃskāra* to the other three dimensions in which we have suggested that human history ought to be viewed. *Śilpa*, *śāstra*, *saṃskāra* and *puruṣārtha* thus form the four dimensions through which all

human history has to be understood and for every human activity we have to ask questions about all these aspects if it is to be fully comprehended.

But even if we take all these into account and forget the central fact of the living, self-conscious, continuity between the past, the present and the future, there can be little doubt that no understanding of history will be possible without the continuity involved in the notion of the preservation of the memory of the past in the present and its prolongation and perpetuation into the indefinite future. The history of a culture therefore has to be seen in terms of what it continuously tries to preserve and pass to successive generations, and in terms of which it prides itself or tries to build a positive image of itself. This is what a culture recounts in numerous ways just as a human individual tells and retells one's own achievements to give one's life a sense of worthwhileness and meaningfulness. As the personal memory continually edits what really happened in the past and forgets and suppresses what it considers irrelevant or that of which it is ashamed, so does a culture edit and repress the memories of its own past. The history of a culture therefore has to take into account not only of that which is preserved and transmitted and of which one sings in myriad forms, but also that which has been left behind or ignored or suppressed from explicit consciousness. However, as it is well known, that which is suppressed does not cease to be active or influence the manifest content of consciousness, whether it be at the level of knowledge, feelings or actions. And that which is forgotten can always be recalled and remembered in case the present circumstances require it. There are, of course, circumstances when one may suffer from amnesia or where things are beyond recall for other reasons.

The idea of the 'return of the repressed' or of 'civilizational amnesia', or of the repression resulting in diverse neurotic and psychotic formations deserves to be explored in the context of civilizations and cultures. In fact, all the defence mechanisms that psycho-analysis has elaborated in the case of the individual psyche, and the relations between the ego and the superego on the one hand and between the ego and the id on the other, can be meaningfully extended to the study of the history of civilizations and cultures. Civilizations may in fact be characterised in terms of the dominant defence mechanisms that they use to suppress the memory of an inconvenient past and the guilty conscience they suffer from because of having done what a new value apprehension tells them that they ought not to have done in the past. The retroactive negative judgement and the guilt following therefrom have hardly been investigated either by psychoanalysts or the historians of cultures and civilizations. But it is one of the most important phenomenon determining one's relationship to the past both at the indi-

vidual and the collective level. The whole task of colonialism, for example, or of the 'immorality' of conquest and war, or of enslavement of peoples other than one's own which are such a dominant feature of contemporary consciousness have radically transformed the perception of their past on the part of many of the contemporary cultures and civilizations. It was not long ago when the Ministries of Defence were called Ministries of War and when to be imperial was considered a matter of pride by a nation. Not only this, it was considered the duty of a king to enlarge his territories and conquer other people. The same is the case with the new values of egalitarianism which demand that all be treated equally irrespective of their race, caste, gender or profession. This has never obtained in human history, but, retroactively, all living civilizations today feel embarrassed, if not positively guilty, about what they did in these respects in the past.

The problem of a new value apprehension retrospectively changing one's judgement about what happened in the past and making one feel happy or guilty about it creates a problematic for historical consciousness which has seldom engaged the attention of the past or present practising historians. If, for example, a new value apprehension in the present can transform our apprehension of the past, then surely the new value apprehensions that occurred in the past would have transformed their own apprehension of what then was the past to them. The history of a culture and civilization may itself therefore be seen as consisting of successive acts of new value apprehensions which have transformed the apprehensions of the past and the way it has been preserved and transmitted to successive generations in the light of this transformed evaluation of itself.

Seen in this perspective, the history of civilizations gets a new twist which is normally absent from the history of human individuals. Normally, the theory of repression postulates an event which occurred in the past because of a feeling of guilt regarding what one had done or thought or felt. It is never supposed to be a retroactive action of the present consciousness on the past which itself is now seen in a different way because of something that has occurred in the present and which influences and transforms our judgement of the past. The need for the repression of the past occurs because of the changed judgement about it in the present and not because it was judged to be such when it had occurred in the past. This however raises a radical problem of a different kind, i.e., if, retroactively, a change in the present judgement of the past can lead to its suppression from the historical consciousness then can a future change in the judgement about it, release it from its repression or obliterate the effects of that regression?

But once the past is evaluated in terms of the value apprehensions of

the present, the history of a civilization itself begins to demand to be seen in terms of the successive value apprehensions that it has had in its historical career and the way its own 'smṛti' or memory has been transformed by these emerging value apprehensions. A new value apprehension, however, does not merely affect the apprehension of the past but also demands the actualisation of that value in the concrete circumstances of the society in which such a value apprehension has occurred. Thus the history of a civilization would be a history of its more or less successful attempts at actualising the value so apprehended. However, the attempt at the concretisation of the value, which has been apprehended, not only spreads from one domain to another and thus permeates the whole culture but also gets transformed in the process and thus changes at least to some extent, the nature of the value apprehended earlier. It may be presumed therefore that a value apprehension is changed to some extent by the attempt at its actualisation and thus the history of a civilization may be seen in terms of the successive changes in its value apprehension by the attempts at their actualization. However, as this change itself will result in a different articulation of the value concerned and in its own turn demand an actualisation, the cycle will be repeated once more. The history would therefore consist of an articulation of the modification of the transformation in the value apprehended over a period of historical time through its successive articulations at both the level of concept and image along with its interactive relationship with the history of events and institutions which will be more concretely reflected in the legal, social and political texts and events of the civilization. The philosophical and the religious texts of a culture articulate the value apprehension at a conceptual level while works of art and literature embody it more at the level of image and feeling. The two together would thus provide a clue to the changes that have taken place in the value apprehension over a period of time. The texts dealing with law, politics and society and the chronicle of actual events and life histories as recorded would provide the concrete commentary on those very values by disclosing how they were actually embodied in the life of the people. The two, however, should be seen not as isolated from each other but rather as interacting with one another at various levels just as they do in the life of an individual. The demand for a close-knit correspondence, however may be mistaken as in these matters there can only be a tendency towards some sort of approximation and given the nature of life as it is lived, even large discrepancies may be expected to obtain. There would however be attempts to lessen the discrepancies as without some such attempt the very notion of the unity of a civilization would have to be given up at its foundations.

While the words remain the same, their meaning changes radically giving the illusion of continuity even when there is little or no continuity whatsoever. On the other hand, the extension may merely develop what was already implicit in the concept and not attended to or focussed upon earlier. At a deeper level the key concept or cluster of concepts which were supposed to embody the value apprehension earlier may be seen as only particular specificities which neither exhausted the meaning of the value concerned nor articulated it adequately. The dramatic story of civilization and culture thus may be seen in terms of the successive transformations in the apprehension of the same value over a period of time or of a number of values mutually influencing each other's apprehension as evidenced and displayed in conceptual, artistic, legal, social and political history of a civilization.

A value, however, is only a possibility whose actualisation is limited by the biological framework of human living and the technological knowledge available to man at a particular moment of history. There is thus a double constraint on the actualisation of the value apprehended, one deriving from the constant given structure of what man is as a biological creature, the other being a variable depending on the nature of knowledge and skills available at a particular time. Both knowledge and skill are extremely varied and while some of the knowledge results in the creation of technology which enables its use in the service of the actualisation of a value, others do not so directly, except in the sense that the pursuit of those kinds of knowledge and their refinement and development over a period of time by successive generations itself becomes a value. Skills on the other hand are traditionally learnt and passed on from those who have them to others, being modified in the process of transmission and being changed due to changing circumstances. The possibility inherent in the situation is thus the product of three different factors, two of which are relatively more constant over a period of time while the third varies over time. Man's biological situation is a given constant in which even the possibility of any change could not be conceived till very recent times, and even in the perspectives opened by the new devices of genetic engineering, artificial insemination, test tube babies, foetus development outside the womb, voluntary sex-change, brain and memory transplantation along with transplantation of other organs in the body, it is not quite clear how these would affect the basic biological structure in which human beings have lived until now. It is difficult to imagine how the cycle from birth to death would be affected in any radical sense by all these changes or the structure of human consciousness which is confined to the present and functions with memory and hope or fear in relation to the past and the future. Nor is it clear how human relations which are the major cause

of joy and sorrow in the world and in whose matrix one lives could possibly be affected by any of these changes, some of which have already taken place and others which are on the cards and are bound to be widely prevalent within the next few decades.

The value apprehension also seems equally constant over a long period of time, though there can be little doubt that new values emerge in human consciousness and, as we have already pointed out, older values get new dimensions and meanings added to them both in the light of new values apprehended and the successive attempts at their own realization. The values of equality, justice and freedom, for example, have undergone a radical transformation in their content in recent times just as the ideal of international relations between states, societies and peoples has achieved a mutation which never existed before.

But, even so, though the value apprehension does not seem to be as constant as the biological nature of man, it is still far more constant than the knowledge and skills he has which seem to inevitably change by their very process of transmission over generations. These continuous changes thus pose a continuous challenge to enlarge the realm of possibility with respect to the actualization of values in the life of the human individual and the society in which those values have been institutionalized to some extent or other.

As against the biological structure of man and the value that he apprehends, the dimension of knowledge and skills has a cumulative character and shows a continuous change by the very logic of the way it is acquired and transmitted. There are of course occasional lapses, particularly in times when either because of sudden climatological changes or large-scale epidemics which decimate a substantial portion of the population, or of wars and political upheavals, substantive discontinuities occur in their preservation and transmission. And though these have not been infrequent in history, there have been numerous instances to substantiate that what was so lost has been recovered later at least to a large extent and built upon to carry the knowledge further.

The case of skills is a little different from that of knowledge as they are far more intimately related to the specificities and exigencies of the situation in which they are exercised. Their very exercise leads to relative modification so that they may become better suited to the context in which they are being applied and towards a more efficient performance of what they are supposed to achieve. And, as the needs of men and the circumstances in which they are sought to be fulfilled do not change very substantially over large periods of time, the skills which are required for living at

various levels do not get lost but rather show a significant improvement with the passage of time. However, if new needs come into being replacing the old or the physical and the social circumstances alter radically, old skills may become obsolescent and new ones take over. But, even in such a situation what generally happens is that there is not a complete loss of old skills, but rather their relative enfeeblement and attenuation in a culture where fewer people know how to exercise them or find occasions and opportunities for their actual exercise. In fact, normally if a demand for the exercise of such skills arises due to any reason, there generally are found persons who can exercise them at least to some extent.

The knowledge and the skill dimension of cultures thus provides that dynamic motive power which produces a continuous change in the history of civilizations, changing the ways in which the basic biological needs are satisfied and the way values apprehended by a culture are actualised. Knowledge and technology however play not just an instrumental role where the goals for them are set by the values apprehended along with the biological structure of living. On the contrary, they themselves bring new possibilities into the horizon of human consciousness and give not only a concrete content to the values apprehended but also make men aware of the valuational possibilities implicitly inherent in the earlier value apprehension. The role of knowledge in this respect is far more positive and integral as it provides both a critical and a creative dimension to man in his apprehension of causal knowledge on the one hand and of the values that he apprehends on the other. The critical self-consciousness operates not only with respect to the values and purposes that are apprehended and thought worth realizing. Knowledge itself has an immanent ideal of its own and a self-conscious reflection on it leads to the question of the relationship between the ideal immanent in knowledge to the other ideals that man pursues also.

Besides knowledge and skills, the one other factor which lies at the roots of change in any civilization is what is generally known as imagination which may be seen in its dual aspects, the one being dissatisfaction with the present as it obtains and the second consisting in an image of the desirable which one would like to occur in its place. The dissatisfaction and the idea of the desirable, though closely related, are also relatively independent of each other as even when one is not dissatisfied one may imagine other desirable possibilities which one may like to actualize. On the other hand, even while dissatisfied with the situation in the present, the direction of its removal may be different with different persons or even with the same person at different times. In fact, imagination is continuously present in all activities of man, but as it plays a subsidiary role, it is not explicitly evident

all the time. In the cognitive enterprises, it occurs at the level of the formulation of hypotheses and these days even more explicitly in the building of models and ideal types for the understanding of phenomena. At the level of feelings, it occurs both at the level of desire and at the level of dreams, including day-dreaming. Day-dreaming is a constant feature of human life, yet it is almost totally ignored as a significant activity of the human personality. In the context of action, it functions in terms of projects and purposes which one attempts to actualize. However, beyond all these the realm of imagination *par excellence*, where it comes into its own and is there in the forefront for everyone to see, is in the world of art and literature wherein man explicitly emerges as a creative being and wishes to be recognized as such. The relation of art and literature to the world of feelings and emotions is well known, but its relation to knowledge on the one hand and action on the other has usually been neglected or underplayed. The works of art and literature provide models both for understanding human life as it is lived by people as well as those which provide ideals to be emulated and translated into life. The point is that the works of art and literature perform simultaneously a double function i.e., they provide a cognitive understanding of life as it is existentially lived and provide norms in terms of which the life of feeling and behaviour of individuals may be ordered and organised. A great work of visual art, whether in the field of architecture or painting teaches you to look in a new way while new forms of music and dance teach one to be sensitive to new rhythms and kinds of dynamic, spatial and temporal organizations. Literary creations continuously provide new models for human relationship and shades and nuances of feelings and emotions that one may possibly feel, live through and enjoy. They also present types of behavioural worlds which one may create in one's own life along with an awareness of what language can do to create moods and shades of feeling which one could not have been imagined on one's own. There is, in fact, an interesting relationship between music on the one hand and certain forms of literary creations, particularly poetry, on the other. There is however a fundamental difference between the two which perhaps has not been sufficiently noticed. The world of feelings, emotions and moods created by literature is so much entwined with the meanings of words that the world so created has a transparent intelligibility or an intelligible transparency which the dumb world created by music totally lacks. Moreover, the world created by music seems to be a succession of feelings, moods and emotions which, though satisfying in themselves may not, and generally do not, create a coherent world of feelings. A literary creation on the other hand normally produces a far more coherent world than the world created by a particular

musical creation. One reason for this, perhaps, may lie in the necessary linkage of a literary creation with the world of meanings which, if it were to be incoherent, will not produce anything at all.

The relation of cultures and civilizations to imagination has been seldom explored. Imagination however, does not only give rise to art, but also is the source of desires and dreams in which men dwell and which they carry in the innermost recesses of their heart. But if it is so, then no adequate history of any culture or civilization is possible unless one takes the world of desires and dreams seriously and sees it to be as much an integral part of man as the other dimensions talked about earlier. To understand a culture or civilization therefore we have to ask, besides the other questions relating to what we have called *śilpa*, *śāstra*, *saṃskāra*, *puruṣārtha* and *smṛti*, desires and dreams, which underlie half-hidden in the creations of a culture. It may be noted in this connection that desires and dreams are different from the realm of ideals, values and purposes which we have called *puruṣārtha* and which man also seeks. This would become clearer if we see the relation of desire to dreams, both day-dreams and dreams that occur in the night when one is half asleep. This world normally does not express itself in ordinary day-to-day behaviour and hence has generally not been the subject of historical investigation. It is expressed more through works of art and literature, and through those special festivals, where man takes a holiday from his day-to-day-life and enacts a world closer to his desires and dreams. However, even the world of art, literature and dionysian festivals expresses this world in a modified form, for even in these realms, constraints of another sort continue to operate. There is the demand for aesthetic beauty and artistic form as well as social paradigms of celebrating the festival. One would thus have to intuit the realm of desires and dreams which is displayed in them through the successive changes that occur in these domains over a long period of time. Normally, it is assumed that the realm of desire and dream, rooted as it is in the unconscious, is as unchanging as the unconscious itself, but it would not be correct to assume this as both the notions of the unconscious, whether personal or social, are themselves a construct inferred from such phenomena as dreams, memories, mental illnesses, slips of pen and tongue, jokes etc., and hence cannot be given as a ground for their unchanging character. Their rate of change may of course be slower but there seems no *a priori* reason for assuming that they do not change at all. At least, it should be treated as an empirical matter subject to investigation and not assumed as has been done unto now.

Imagination however plays an active role in almost all human activities, including those that relate to desiring and dreaming. Its role in cognition

is as important as in the realm of feeling and action. It apprehends a possibility and may or may not try to change it into an actuality or embody it in a form that may be apprehended objectively in an inter-subjective or interpersonal manner. In the realm of desire and dream, imagination is satisfied by the activity of imagining itself and is not interested in either embodying itself in an objective medium or transforming the actual according to it. Being perhaps the most subjective of all activities, it would be interesting to find the differences in it across cultures and civilizations and the changes in it, if any, over a period of time within a culture or civilization. The idea of a collective or racial unconscious resulting in similarities of myths and symbols across cultures and civilizations has fascinated a number of thinkers, but it is not quite clear if there really are myths or symbols belonging to mankind as such, or to which men in all cultures and civilizations respond uniformly. The fact, on the other hand, seems to be that most people's responses are limited to the myth and symbols they have inherited in their culture. There is always a possibility of widening the horizon to include those of other cultures and civilizations, but such possibility remains secondary to one's own psyche, except perhaps in very special circumstances.

The relations between desire, dream and imagination are thus far more complex than may be thought of at first sight. Their relationship to the more objective and easily identifiable pursuits of man in the realm of cognition are not so easily discernible, but their silent shaping presence can always be visible underneath the surface of things to a discerning eye if it is sensitive to them. The word or words for these in a culture or civilization will themselves be an interesting indication of the fact as to how it has perceived this dimension of the human situation and its historicity, if any. The Indian tradition seems to have no clear-cut term to indicate what is usually conveyed by the terms 'desire' and 'dream' in the English language, at least in the sense in which we have been using them in the discussion. The closest terms are *vāsanā*, *bhāvanā*, *swapna* and *kāma* or *kāmanā* which themselves have resonances of a different order. There is the notion of an *anādi vāsanā* or beginningless desire rooted in *avidyā* or primal ignorance, supposed to be the cause of the creation with its temporality and plurality. It may be overcome only by overcoming desire and the dream world or worlds it creates. The idea of a world coming into being through the force of desire just as the ordinary dream-world manifestly does is interesting in itself, particularly as it makes one ask as to what is the desire which is the root of a particular world and which is sustained by it. It also draws attention to the fact that the world will collapse if the desire which creates it ceases to

operate, or another desire takes its place. The difference between the ordinary dream-world and the other worlds in which man also lives is generally supposed to be in the fact that those other worlds have an interpersonal or inter-subjective character shared by many persons. The analogy with the dream-world created by a purely personal desire would, or should, lead us to postulate a common world of desire among persons who share that world and who have thus jointly created it. It is the commonality of desire therefore, that, in this perspective, is the root of the commonality of the world, and if one, for some reason or the other, gives up that desire or withdraws from it, then one ceases to be a member of that world or, in other words, the world ceases to be the world for that person. This may seem a little too complicated but it only reflects the simple fact that when one ceases to be interested in a particular domain it ceases to exist for him, at least existentially. The whole world of knowledge and scholarship, for example, does not literally exist for anyone who is not interested in it. Nor, for that matter, does the world of the stock market or high finance or politics or the world of the military exist for anyone who is not in it. There is of course a common world which all these worlds presupposes, and which most men share at least to some extent, but then that is not the world in which one lives *in a meaningful sense*. The world which has significance and meaning for one is the world that one carves out or rather that which one helps in creating by one's interest, which is only another name for desire.

It would be interesting in this perspective, therefore, to ask what are the worlds that men have created and lived in, in the history of a culture or civilization, and how their predominance and relative strength and importance with respect to one another changed over a period of time. These worlds, it should be noted, are worlds only to those who 'live' in them. To the rest they are not worlds at all, but mirages or utter unrealities or delusions, if one thinks about them at all. The whole world of religion is the classic example of such an existential phenomenon. So is the world of sport or art or knowledge or power along with many others which one can think of. The more puzzling and perhaps more interesting fact about these worlds is that one lives and can live in many of them and can shift from one to the other without feeling uncomfortable or strange or disturbed about it. However, one does not live in all the worlds, nor is one normally even aware of all of them. Even within what may be called cognate worlds, one may not be aware of the worlds lying close by or related to the one in which one normally lives. Take, for example, the world of knowledge. Who lives in the many mansions and domains that it comprises? The philosopher may not know much about history and the historian little about philosophy. And, even a

historian may know little or nothing about the history of those cultures, nations, civilizations in which he is not interested. As for the farther fields of mathematics, physics and the other sciences, the little said the better. The point is that one lives in little worlds of one's own and that they alone are the ones that are real to one's consciousness. The relations between these worlds is always very tenuous, and though the cognising consciousness which treats them as objects tries to impose some unifying principle between them, it is mostly an imposed one for purposes of cognitive satisfaction rather than an actually experienced living one for the existential consciousness in which and for which they really exist. The movement of consciousness from one world to another is perhaps one of the greatest mysteries. Perhaps, even more baffling is the phenomenon that the consciousness can *withdraw* from any of these worlds if it so chooses, even though it is not always equally easy or possible for it to do so. In extreme cases of psychotic madness it becomes almost impossible for the consciousness to exercise this function, but the primary postulate of all psychiatric help to the patient consists in the belief that such a freedom can be restored to the consciousness that has somehow been deprived of it.

The problem that this raises for any writer of history of any civilization is to demand from him a delineation of the 'worlds' created by a civilization along with an imaginative capacity to make these worlds living for oneself at least to some extent in the same way as they were existentially lived and felt by the people whose history he is writing. Even more important than this is his attempt to apprehend new 'worlds' which are opened up or created and built by a civilization in its development over a period of time, and the possible relations, if any, between these worlds.

One of the most interesting phenomena in this regard is perhaps on the fact that this characteristic activity of consciousness itself may become the centre of attention in a civilization and result in an attempt to develop this capacity of consciousness to its fullest extent and explore its implications in diverse directions. The development of civilization in India may be said to have been specifically characterised by this peculiar development. Its history may be viewed as successive attempts at the exploration of implications of this phenomenon along with a theoretical reflection on it. The vantage point that such an attempt enjoyed in the Indian civilization, the role or roles it played in its development and the way it affected the other worlds need to be investigated and studied.

The primacy of a particular 'world' over others or even of the capacity of withdrawal of consciousness from all 'worlds' would thus give a civilization its distinguishing feature and the different phases of that civilization

would be seen as marked by the dominance or primacy accorded to some world or worlds over others. Such a primacy can be inferred by both the quantitative and qualitative evidence that a civilization has left behind. It will, therefore, be simultaneously concerned with the actual behaviour of a people with respect to the world that they regard as primary as well as the valuational status that they ascribe to the hierarchy among the different 'worlds' they regard as meaningful and significant.

The notion of the 'world' or rather 'worlds' that human beings create seeks to emphasize what historians normally tend to underplay and which most human societies tend to ignore. This is the role of man as essentially a builder or creator of his world or worlds within the larger given world in which he has been playing the role of building civilizations for quite some time. And once we begin to see man as a creative builder, we begin to see history in a different way and see the past as a series of creative constructions with all their limitations and achievements. Further, to see man in terms of his creativity and the capacity to build diverse worlds is to see history as necessarily indeterminate and indeterminable in principle. The judgement that we will bring to it will also be different in such a perspective. It will be more akin to the way we apprehend works of human creativity, the paradigmatic example of which is art, and thus civilizations will be seen more as works of art than anything else. However as all creativity is exercised within a tradition, the history of a civilization will be seen in terms of what successive generations have made or built out of what they inherited. The past sets both standards of excellence and achievements and hands over unfinished tasks and unsolved problems in all fields of human endeavour to the succeeding generations. These attempts themselves, even when successful, give rise to new problems, set newer tasks for the next generations. The history of a civilization therefore would simultaneously articulate the norms and standards laid down in fields of human endeavour and articulate the uncompleted tasks and unsolved problems which were left by one phase of the civilization to another. It would also emphasize the apprehension of new problems, both arising from the solution of an old problem and the apprehension of an entirely new one by some real innovator in the domain concerned. Beyond these it would also try to see the interaction between the different domains and how developments in one field tended to affect and be affected by those in others.

The identity of a civilization in the course of its onward development in time and space changes its form when it gets contrasted with those of other civilizations and cultures. The identity of a civilization is thus not only

internally apprehended but also apprehended through its external contrast with other civilizations. The contrast between the internal and the external occurs in a double sense. The first relates to the fact as to how a civilization views itself, while the second relates to the fact as to how it is seen by others. However, as others are not one but many, there are, so to say, multiple mirrors in which the same civilization is reflected and seen. The picture of any civilization therefore will have to be built by a conflation of all these images, both external and internal to itself. The internal images may also be as diverse as the external ones, for the civilization is not viewed in the same way by all its members, nor in the same way at all periods in its history. The successive images, both internal and external, would thus form a history of the way a civilization has perceived itself and been perceived by others. Appearances are the reality in this context as in many others. The challenge is to become aware of the diversity and the changes in them over space and time and see how much they overlap and how much and where they differ.

At the root of a civilizational identity, a creative person's or persons' formulation of a vision functions in the history of that civilization like the Big Bang theory does in the creating of the universe. The question what preceded it is irrelevant, because it is the defining point of the study of a civilization as we apprehend it. The vision however is generally embedded in images and concepts and sometime in symbols and artefacts which themselves provide an inexhaustible source of an ever present fecundity for the whole successive history of that civilization. To understand a civilization, thus, is to see the images and concepts or the symbols and the artefacts as static and closed, treating them as if they had exhausted all their vitality and dynamism. If the civilization is alive, the images and concepts are *used* and they *continuously* reveal the dynamic creativity hidden in them. The act of 'understanding' any civilization then always tries to see it in terms of its past, while the active participants and builders of the civilization always look towards the future and try to link meaningfully what they want to bring about with what has already been achieved by their civilization in the past. There is therefore a continuous tension between articulation of the identity of a civilization in terms of what it has already accomplished and what it is trying to achieve in the present. Its dreams and aspirations, despite some relation with the past, are not completely determined by it and may even be at variance with it. In fact, even the reconstruction of the past story of a civilization will have to take into account the successive changes in the functions performed by the foundational images, concepts and symbols in which the original vision was embodied and the inevitable changes intro-

duced by the active and living use of them in the successive periods of the history of that civilization. The identity, thus, is in a very real sense the identity of the name and the form given to the image or a concept or a symbol just as the identity of a person lies in the name that he or she has even when he or she changes over a period of time. Normally the changes are gradual, but when they are radical and sudden, we tend to ask questions about the identity of the person concerned. And just as the identity of a person is a living identity, consisting of so many dimensions such as habits, gestures, ways of looking and feeling and acting and myriads of such other things that make a person different from all others, so is the identity of a culture when it is alive. And, as all these are unified in the name and the form that he or she possesses, the same is the case with civilizations also. To apprehend its identity, therefore, is to capture both the original vision as embodied in the symbols, concepts and images that we find at its beginning, along with the successive transformations they have undergone at different periods of its history as well as the addition of new symbols and concepts that have come to dominate and modify the previous concepts, images and symbols thus giving them a new meaning and significance.

A civilization, as we said earlier, is not an isolated entity. Rather, it exists among other civilizations with which it has an active interchange and which it encounters through war or trade and commerce or in other ways. The interaction involves a borrowing of not only goods but also of techniques, ideas, knowledge and sometimes even values, including styles of life and what is regarded as worth pursuing in life. The spread of religions, techniques and knowledge of both an empirical and transcendental kind is well known. So also are the borrowings in the field of art, architecture, languages and articles of food and dress, styles of cooking and other such things over a period of historical time. The problem of the identity of a civilization thus becomes even more complicated when it is seen in terms of this active interchange which goes on all the time. The problem is more akin to the identity of a personality which is in continuous interaction with other personalities from whom it is continuously influenced and whom it influences all the time. The identity in such a context is provided by what is rejected and how what is accepted is modified to suit one's own vision and tradition. The identity of a civilization therefore would have to be seen in terms of what it has rejected in its encounter with other civilizations and, more importantly, how it has modified what it has borrowed from other civilizations or, in other words, how it has transformed the external into the internal, the alien into the traditional. The spread of religions across continents and the modifications they have undergone as they have moved from the centers of their origin

to other climates, civilizations and peoples provide a classic example of changes that a central vision undergoes when confronted with challenges from other civilizations. The example of changes in art and architecture are another illustration of this very kind. At a more ordinary level the same may be seen in styles of cooking and dress as they spread from one cultural zone to another. The problems posed by the spatial spread of a civilization are as important as those of its development in time.

Culture and Cultures

G. C. PANDE

There are three major approaches to culture, which may be called the scientific, the historical and the metaphysical. The scientific approach is essentially modern and is exemplified by the social sciences, especially anthropology and the sociology of the mind. The historical approach is both modern and traditional, depending on one's conception of history. The metaphysical approach is essentially traditional and has two varieties. One of these identifies metaphysical or transempirical truth with the systematic content of orthodoxy. The other identifies it with the content of mystical revelation or intuition.

It is this last approach which seems to me to be the nearest to culture which would then be essentially nothing but the tradition of *philosophia perennis*, *sanātana dharma* or *ārya-mārga*, a universal and perennial but occult tradition of wisdom (*amṇaya*, *vidya*) which has been diversely interpreted and expressed in different symbolic traditions (*agama*) of value-seeking (*puruṣārtha-sāadhanā*, *ārya-paryeṣaṇa*) embodied in historically given societies or civilizations.¹ This would immediately appear to be open to many objections. Anthropologists, sociologists of culture, and historians of civilizations are apt to find this idea of culture somewhat Pickwickian. Most modern philosophers and Western specialists of comparative religion as well as traditional theologians generally would find the idea of a universal and perennial tradition of wisdom, which is not to be identified with any of the historical traditions of religion and morality, as unwarranted and, in fact, without substance. That historic civilizations are rooted in inner spiritual

culture would appear to be an unprovable supposition. That their religious and moral culture is a particular reflection of a universal tradition of wisdom, would appear, if possible, even more speculative.

Before turning to details, I would like to give a general reply to such objections. The idea of an occult tradition of wisdom accessible to earnest seekers anywhere is an idea which has been endorsed by many spiritual Masters. It seems to me to correspond to the needs of human spiritual seeking and to offer a plausible explanation of the parallelisms between diverse historical traditions. One of the lessons frequently drawn from a genuine study of the history of ideas and cultures is that of the relativity of dominant intellectual perspectives to organized social practices, including institutionalized values. Underlying this overt structure of culture may be discerned a much vaguer, but none-the-less significant outline of what has been popularly called a philosophy of life or *Weltanschauung*. As an operative idea of life as a whole it enters into the making and working of institutions. As faith it guides the individual's quest for what is right and authentic, what constitutes excellence and the ultimate good. As a fragmentary glimpsing of cosmology and anthropology, a metaphysic, essential but without formal definitions and system, it functions as the matrix of fundamental suppositions for the thinkers of the age. This basic faith or *Weltanschauung* itself springs from an intuitive vision or revelation of an essentially spiritual character which is inseparable from *praxis* and being expressed symbolically enters into the social tradition. Vision (*vidyā*), *praxis* (*sādhana*), tradition (*agama*), structure of norms and principles of practice (*dharma* and *nīti*) constitute the underlying basis of a culture or a distinctive macro-society.²

Turning to the initial semantic question it needs to be noted that the use of 'culture' is itself culture-relative and its understanding depends essentially on intersubjective communication. Without going into the controversies over word and meaning, I would like to premise that the origin of language lies in the expressiveness of consciousness and that meanings are neither real objects nor mere usage but contextual constructs, a means of constructing worlds: structures of interrelated objects and subjects: while dealing with the experience of reality in diverse ways. It would be necessary to distinguish the type of context in which a word is used to determine its meaning. There is the commonsense use of plain words like 'yellow' or 'tree' referring to physical objects. The context may be described as the practical-cognitive context of interaction between man and the natural world glimpsed in sensory experience. The dictionary meaning of such words is definite enough and the nature of the classes of objects to which they refer is a matter which may be determined by empirical research. Although such words are

used by common people and the specialists alike, the latter know more about the nature of what is meant. The painter and the student of optics, the gardener and botanist clearly know more about the nature of what is meant by 'yellow' or 'tree'. Such words are primarily constructive devices to recognise, identify and demarcate classes or subclasses of sensory objects. The meanings of such words thus are definitely ascertainable and communicable though they are connected with an area of growing and corrigible empirical knowledge.

Such names as 'Rāma' or 'Kṛṣṇa' are on quite a different footing from class words since they not only refer to some particular demarcated from all other members of its class, but to an entity which is the sole example of its identity. Names cannot be translated and, what is more, someone must give a name. Indeed, a name in this sense can properly belong only to a sentient being who recognizes it, though by extension one might even name what belongs to such a being. In the case of class words, the knowledge of their meaning begins with acquaintance but progresses in terms of descriptions based on empirical investigation. 'This is that', or *Niloyam*, is the paradigmatic case of the use of the common descriptive language which is the tool of practical-cognitive activity classifying empirical objects as part of man's interaction with the natural world. In the case of names, however, one might recognize what is named through the description of some 'accidental' property but it is through a growing acquaintance that one might learn to truly recognize the meaning of the name where sense and reference coincide. 'I am I' is the paradigmatic case of naming which belongs to the evocative language of personal affective relationship. *Sumirat nāma rūpa binudekhe āvat hṛdaya saneha bisekhe.*

Definitional words like 'circle' and 'atom' belong to a technical and abstract part of the pragmatic-descriptive language, a part which may be said to be theoretical-speculative. While the meanings of such words depend on the definitions, the definitions themselves need to conform to the nature of the objects meant, which are discovered in the process of seeking to know natural objects better. While the ontological status of the objects meant by definitional words lacks the contingent actuality of natural objects, it has a necessary aspect which is yet relative to some specific context of abstraction. These meanings too are definitely communicable and tend to be alike in similar contexts interculturally.

In contrast to these uses where words refer to physical or ideal objects which may be apprehended perceptually or logically, words like 'epic' or 'gentleman' appear to have only a conventional meaning which may be apprehended only as items within some particular world of opinion. The

conventional nature of the force of such words, however, does not mean that the conventions are arbitrary. They are often expressive of some intersubjectively recognized sense of psychic reality or its modes and attitudes, social or aesthetic, moral or religious. The emphatically conventional character of the signification of such words merely reflects the need of intersubjective attestation in the apprehension of their meanings which are neither purely objective nor purely subjective. The objects meant are inaccessible to mere sense perception or mere logical abstraction or mere subjective feeling, like language itself. They are subjective-objective modes of collective self-consciousness. Their obvious context is that of man's awareness of other selves or persons or of a larger self or consciousness and of the attitudes, relations and forms emerging in the process. It is the context of being, knowing and expressing oneself as associated with others.

This classification of words and meanings in terms of their basic context includes a fundamental division into two classes. There are words describing perceptual or logical objects in a practical or cognitive situation, or words expressing the self-exploration of the intersubjective consciousness of a society. We have thus a class of meanings which could be called inter-cultural constants. These are meanings given to consciousness objectively. Words signifying them in different languages and cultures are, in principle, more or less exactly translatable in specific practical or scientific contexts. On the other hand, there are meanings which are clearly accessible only in social self-consciousness. The corresponding words differ in different cultures and their meanings too are nebulous and variable. No strict parallels or equivalents for these can be found. 'Culture' itself is one such word. All cultures have their own reflective notions about what they are or ought to be, i.e., they have their own notion of 'culture' which comprises a general view of the nature, condition, ideals and means of human life, the proper way of being human.

Although the distinction of nature and nurture, of man's biological and social heritage is an ancient and universal one and is perceived inevitably in the task of bringing up children and governing men, this distinction was generally seen earlier in terms of education, tradition and law which were regarded as of universal and perennial validity, despite the fact that those societies were perfectly aware of the fact that their norms and values did not hold beyond their borders. They tended to dismiss the outsiders as barbarians, identifying their particular civilizations with civilization in general. Men were regarded as properly belonging to the State governed by law and nurtured and disciplined by an educational and moral tradition. They were expected to live by performing their duties and pursuing the good within

the framework of the social tradition. It is this sense of a traditionally given, stable and worthy order which was the counterpart of 'culture' in ancient civilizations.

The traditional notion of culture, thus, was that of the refinement or *re-formation* of human nature in a broad sense. It would be noticed that there are three obvious and interconnected dimensions of 'culture' in this sense. First is the process of improvement (*saṃskāra* or *bhāvanā* or *sādhana*) effected in man as an individual.³ In the second, culture would have the sense of an objective order of rules, goals and symbols belonging to a specific society of men, which impels and guides this transformation of the individual,⁴ and lastly there is the historical tradition of that society and of mankind in general within which the specific social-cultural order subsists as a changing form or structure.⁵

It may be pertinent to remark here that apart from this most general sense of culture as developmental re-formation which distinguishes it from nature, there is another well-known narrower and stricter sense of culture which distinguishes it from society. In this stricter sense culture refers to the ensemble of such activities as language and learning, art and literature, religion and morality, science and philosophy.⁶ What is common to these activities? They have been characterized as symbolic or symbolic-expressive. If the idea is that they use symbols, then there is hardly any social activity which does not. If the idea is that they consist solely in the use of symbols, then it is plainly false because many of the above mentioned cultural divisions include practical and cognitive activities which go beyond mere symbolism. While art and literature could be characterized as symbolic-expressive, such a characterization would be quite inadequate for religion or morality. The distinction between the social and the cultural could perhaps be more adequately described in terms of the goals pursued in them. Society is organized around the pursuit of particular and urgent, but often competitive, interests through practical action and gestures. Cultural *praxis* aims at realizing ideal goals or values. Their pursuit is perfectionist, their empirical-social subject is at least ideally liberated and transfigured.⁷

It would seem, thus, that the meaning of culture as the transformation of nature ranges over many levels. It includes the transformation of a natural being into a social being working for the particular interests of ego and the group with which it identifies itself. It also includes the transformation of a social being who identifies himself by social roles (*Varṇāśramādyābhimāni*) into a spiritual being who identifies himself with self-conscious being in its autonomy seeking absolute values. Instinct and social activity (*pravṛtti* and *vyavahāra*), social ethics and rational policy (*dharma* and *nīti*), spiritual

praxis and wisdom (*adhyātma-sādhana* and *vidyā*), cognitive and creative activity (*Vijñāna* and *śilpa* or *kāvya*) are distinctions which have been differently defined and understood in different traditions. Just as man develops a sense of his subjective identity and projects an image of his personality, so he also recognizes the unity of the human world within which he lives and acts. An intersubjective consciousness in various degrees tends to come about in any society around its identity and its underlying unifying principles. While both the individual and society may be subject to false consciousness, it may still be stated that the sense of culture is the sense of excellence or value in the self and the recognition of an overarching and distinctive unity in the ways of perceiving and doing things *appropriately* in a society.

The current concepts of 'society' and 'culture', 'historic civilization' and 'evolution', 'political revolution' and 'economic development' are hardly two centuries old as are the sciences of sociology and economics, anthropology and psychology. Not only is the concept of culture so-called modern, it is intimately bound up with the notion of modernity. The new sciences view the human tradition not as static or superhumanly ordained or as universal but as the historically evolving particular and multiple product of human creativity and labour. The modern views of society and culture have emerged in response to the awareness of the vast revolutionary change through which man is passing as a result of his own effort aided by scientific knowledge and technology.

The concept of culture in the modern sciences of man is the concept of the form of behaviour in its totality in a society⁸ or of its symbolic-expressive aspect. As behavioural form culture is an empirical social fact which, it is expected, might one day be fully explained scientifically.⁹ Being determined by sufficient social causes, cultures vary in different societies and thus their scientific understanding has to be deterministic, relativistic and pluralistic. Although generally conceived as branches of positive knowledge, the modern sciences of man subscribe to a philosophy of rational or scientific humanism. They seem to believe that implicit in the nature of man is the ideal of a universal culture based on rationality, science, technology, and humanistic values which have been generally interpreted as freedom and creativity, equality and justice, welfare, progress and peace.

These two ideas, the unity of human nature and the ideal of culture, on the one hand, and the multiform plurality of actually given cultures need to be reconciled by some pervasive principle. Modern social sciences attempt it by the ideas of evolution, development and progress. Thus prehistoric cultures are regarded as primitive and the history of civilization as subject to the long-term trend of linear evolution. Human culture, thus, has come of

age in the modern West and is now spreading over the globe. This seems to presage the future unity of human cultures in terms of capability and basic social ideals though it does not exclude diversity in the symbolic-expressive area. Western Europe, for example, has a common civilization today but has many different national cultures with different languages, literatures, arts, etc. Similarly, the erstwhile Soviet Union expected to create a common socialist society and civilization within which many national cultures would be free to flourish. In India it is officially believed that there is a composite culture of many ethnic, regional, linguistic and religious constituents but increasingly a modern civilization.

The current view, thus, is that an actual multiplicity of cultures is due to diversity of developmental and evolutionary as well as ethnic and historical conditions. The ideals of individual, ethnic, and national freedom not only make this cultural plurality acceptable but also desirable. On the other hand, the ideal of development and progress as well as the need of world peace, require the idea of a single world culture. Between the ideas of cultural pluralism and world culture there is a manifest tension. Culture as creatively rooted in freedom posits pluralism as an expectation as well as a value. On the other hand, culture as rationality and capability posits universality. The two dimensions of culture are united by the assumption that a socio-economic order based on techno-scientific capability provides the best means of maximizing the freedom of life-styles consistent with the requirements of social justice and the limitations of social choice.

It may certainly be possible to alleviate specific wants and wrongs afflicting specific persons or groups but will it be feasible to alleviate the wants and sufferings of all persons and groups? Apart from the fact of conflicting interests in a world of scarce goods and limited possibilities, it would be highly unrealistic to think of the *demos* as a homogeneous set of equal numbers, and national interests would in any case claim priority over the interests of outsiders. Can *Vasudhaiva Kutumbakam* be practised without practising *ahincanya*? Has the concept of maximizing satisfaction any concrete meaning outside 'rational' economic activity? Can pleasures be compared, at least inter-personally, and summed up? Can pleasure and duty be compared? Can utility be the sole objective of economic, let alone ethical action? Can values such as personality and freedom, equality and justice, love and compassion be reduced to calculable interest satisfaction? Can they be given any adequate and constant objective content?

It is unnecessary to go on with criticism which has been made before. Culture, it may be recalled, has a dual meaning. It signifies the rational pursuit of security and satisfaction as well as of ideal values. Traditionally,

the former was regarded as a necessity or concession, the latter the true meaning of culture. It was believed that it is the elite (*adhikāri*, *śreṣṭha*) that are privileged to participate in culture which is a stable, perennial and universal order. The actual cultural differences of different societies, their laws, customs or beliefs and arts were not regarded as contradicting the unity and universality of culture, which is an ideal order recognized by the elite to whom its tradition is accessible, not a mere contingent and variable social actuality. In the modern view, however, the ideal of culture is only the limiting conception of the rational development of cultures. The emphasis is not on an old and given tradition propagated by seers and sages, philosophers and prophets, which requires men to believe and act as ordained by it patiently and dutifully since their highest fulfilment does not lie within their mortal career. The emphasis now is on creating and changing the tradition so that men may discover new means of fulfilling themselves on earth.

The foundational assumption underlying this view is that the only valid means of knowing anything originally, available to man are sense-perception and reasoning. So the history of modern thought began with the waning of faith, the rise of scepticism and attempts to formulate the methodologies of knowledge. Humanism and a secular view of life were the inevitable products of this rational outlook which came to be well established between the Renaissance and the *Aufklärung*. All three continue to be the basic assumptions of the modern sciences of culture inspired by the successful application of logical and experimental methods of investigations to nature in the nineteenth century. During the last two centuries the social sciences, or rather the *Geisteswissenschaften* have discussed man, society and culture in their diverse branches and schools divided by methodological as well as ideological disputes. But whether it is the Positivism of Comte and Durkheim, Radcliffe-Brown or Kroeber, or the scientific and historical humanism of Marx and Weber, or the philosophical anthropology of the Critical School, the basic assumption of a scientific rationalist, humanist and secular view of life pervades all of them. These assumptions are not themselves scientifically demonstrable or philosophically necessary for scientific research. They seem to be of the nature of faith defining modernity itself even though they are described as articles of Critical Reason constitutive of any genuine, scientific understanding of culture. Although like traditional views the modern view is itself a particular, culture-experimental meaning-construct, it arrogates to itself the status of a universal scientific doctrine.

That the use of logical methods in all cognitive enterprise is necessary, is unquestioned, but is it true that the knowledge of all real objects must begin with sensation? Is it necessary to regard the positivistic assumption

of natural science methodology as valid for the human or social sciences? For example, the study of psychic reality simply through bodily behaviour cannot be said to go much beyond physiological or psychosomatic studies, nor can it unravel the mysteries of the mind such as is claimed for Yoga. Perhaps it could be argued that modern psychology begins by denying the distinct or independent reality of the mind. Even if the mind were not independent of the body, its awareness as a distinct reality is common to all mankind. Reductionism or indirect causal correlations, in any case, do not further the understanding of the mind in its distinctness or freedom. That the only means of knowledge are sense perception and inference or that all reality must be material are alternative expressions of the same idea which is no more than a highly disputable and implausible philosophy. My knowledge of my thoughts or the positivist philosopher's knowledge of his own philosophy are not the objects of anyone's sensory perception and consequently of any inference. This is so because the association of the imperceptible with the perceptible is not itself perceptible. Thus to seek to reduce the human person to an easily misunderstood construct of his bodily behaviour, seems to miss the most obvious fact about him: his immediate self-consciousness, his being as being-for-self. The human person knows himself immediately and indubitably as the subject of experience, what he thinks of himself as an object is variable and constructed and sometimes, if not always, demonstrably false. What is contended, therefore, is not that there cannot be a science of man; but that such a science cannot be a positive science of behaviour.

Culture has been defined as '*nothing but* an abstraction from or for behaviour'.¹⁰ Now the idea of abstraction implies a loss of reality only on nominalistic assumptions. As a matter of fact, logical abstraction cannot be arbitrary but must be based on the recognition of form in the objects of perception. It must also be remembered that all intelligible forms do not have corresponding physical forms. For example, the temporal form of past, present and future cannot be represented spatially. In fact, the autonomy of forms as intelligible essences has been argued by philosophers from Plato to Husserl. Acute empiricists familiar with mathematics have been puzzled over the derivation of universals from empirical particulars and have had to resort to the illusively abbreviating role of language or symbolic systems. Nor can poetic images be rendered physically. The moon-face is an imaginative, felt form but cannot be represented physically. Ideas, images and symbols, thus, cannot be regarded as being necessarily representations of sensible form. Sensible phenomena are rather held together by immaterial forms or intelligible systems of relations. It follows that culture as

abstracted or symbolic form must be an intelligible form of meanings which cannot be identified fully with behavioural features perceptible in themselves. Nor indeed can human behaviour be understood without reference to meaning and purpose.

The concept of culture as an abstraction from behaviour, thus, signifies not that culture is less real than behaviour but that it is necessary so that behaviour may be intelligible. Culture as abstraction or abstracted form is not an abbreviated or incomplete descriptive schema of real particulars but their idea or standard. It is not an abstract but a concrete universal, the immanent idea or standard of cultural behaviour.

That culture is form or pattern has been widely held. Anthropologists have sought to describe the total way of life of relatively isolated, stationary and face to face societies with a clear sense of their own identity. Now different scientific researchers do not have the same theory of culture, yet they agree on some general features and presume a certain notion of cultural form. In general, these theories assume man to be a wholly natural creature and the form of his culture to be socially determined and historically evolving. Thus cultural form has to be regarded as an empirical fact constituted by a complex set of inter-related variables, dependent on causal-formative processes. Among these processes scientific knowledge, technology and natural environment are given the pride of place, though these factors become operative at any point of time within the parameters provided by organized society itself as a 'reality *sui generis*'.¹¹

However, it is the common experience of mankind that the causal determinants of human behaviour include the free will of man. In what man does or makes the idea of the object or the product, again, is an important kind of cause, the formal cause of the effect. And even if final causes are ruled out in nature, they cannot be ruled out of social behaviour which is pervaded by purpose. Freedom and design, meaning and purpose are integral moments of social action of which the forms or patterns cannot be derived merely from the knowledge of the physiological or instinctive nature of man. The drives of hunger or sex do not determine the modes of production and cooking or of marriage and family, much less the artistic representation or philosophical conception of labour or love. Given a state of science, alternative technologies are possible and the choice between them has to be made on non-technological grounds. Nor does technology uniquely determine the forms of culture as culture or value-seeking. The paintings at Altamira or Ajanta, Sistine Chapel or on the canvas of Picasso belong to vastly different technological ages, but these have little demonstrable connection with their aesthetic value or immanent intention.

It may be argued that the growth of science and technology gives man knowledge of his own reality and greater control over the natural environment and thus the ability to realize his own freedom better by rationally fashioning the forms of his culture. The forms would be constituted by the rational adaptation of real and effective means to the genuine ends of man as understood in the light of scientific knowledge. As stated before, culture would then be the rational form of life to be attained progressively. In its archaic and traditional forms culture was organized around the delusions of myth and ritual, theology and metaphysics and various other kinds of ideologies. Owing to the arbitrariness of speculative fancy, the diversity of environments and the accidentality of history, these cultures exhibited much diversity of forms at the collective level but did not permit much freedom at the individual level. On the other hand, the future culture of the scientific age is bound to display universal rational forms and at the same time permit great freedom in personal life-styles, a proposal of which the attractiveness was mentioned before.

These arguments, however, appear to be extremely simplistic. The increasing power of man over his natural environment has not given him a comparable power over his own social and cultural environment. It has not given him any mastery over himself or any wisdom about the perennial questions of life and death which he cannot avoid asking. It tends to project man as a natural object for which neither consciousness nor death can have any meaning. It obscures the basic question of the authenticity of the form of life by that of its scientific organisation in the context of objectifiable ends and means best illustrated in current economic science and policy. The real question about the form of culture relates to its meaningfulness and authenticity, not its efficiency, nor yet to its sheer *facticity* as a causally determinate product.

If one argues the continuity of nature and culture and the value-neutral character of nature, culture would have to be held an impossible illusion. How can blind natural forces produce a self-conscious moral being? If they can, can they be really blind, unconscious forces? Whatever the authenticity of the concept of natural evolution to natural species, it does not apply to human societies and culture in time because evolution is supposed to operate through genetic mutation, not acquired social heritage. The evolutionary formation of human cultures is only their historical formation. The question, however, remains—is the result of such a process a consistent form or pattern or merely a congeries of heterogeneous elements and processes?

Take, for example, the debris of a burnt down palace buried under the earth, or for that matter, the whole of the human past buried under the earth.

The archaeologist needs to identify each part of it separately and seek help from the relevant science in understanding it. The archaeologist doubtlessly notices diverse characteristic forms in diverse areas of human activity in different ages, tool-forms, ceramic forms, graphic forms, settlement patterns, art forms, etc. He also notices some interconnection between different forms in an age or culture and is thus able to identify, for example, a newly discovered site as Harappan or non-Harappan. But such multifaceted, multi-dimensional forms or identities of historical individuals cannot be reached by any theory since their origin lies in the accidental coming together of numerous, disparate causal streams. The notion of form in the scientific sense is hardly relevant here.

Nevertheless, the sense of an overarching form in a cultural epoch or community has often been shared by archaeologists, ethnographers and historians, despite their varied perceptions. What is really perceived is some kind of a suggestive protean unity in a culture which changes but persists, despite accidental changes. Thus, the family or the worship of gods has persisted over millennia. So, many complex structures of such elements have survived for long ages as historic civilizations. The unity of such structures may be derived from the social inter-dependence of those who engage in cultural activity coupled with the dominance of certain ideas and attitudes, which itself has been attributed to the dominance of some social classes or alternatively to the influence of moral, spiritual, or intellectual leaders. This unity or *Zusammenhang* has been sought to be rooted in the patterns of values, a *Weltanschauung* informing the *Zeitgeist*, a cosmology, or the absolute presuppositions of thought, a phase in the realization of the Absolute Idea. On the other hand, it has been attributed to the deterministic influences of the natural environment or the techno-economic substructure of society, or the inherent structuralizing tendency of the human mind.

Such theories which seek to define the nature and source of cultural form fail to reflect that there is a basic difference between two types of unity, subjective and objective. Where the object is not a mere aggregate but a distinct whole, its unity depends on the orderly interrelation of its constituent parts which in the case of actual objects have to be elements in a dynamic causal process. Thin strands of a thick string cooperate to give the latter its strength. Hydrogen and oxygen atoms combine to produce water. Different notes produce a combined melodic effect. The unity of the complex object as a whole is understood in terms of the systematic operation of causal rules discoverable empirically. In the case of ideal objects or abstract creations there is an essential identity or identity-in-difference between the whole and its parts, and its constituent relations may be in principle fully

analysable, as in the case of mathematical forms, but may not be so in the case of imaginative creations which are not as a matter of fact primarily objective forms but significant forms imaging subjective unity. 'Although being for the subject is the foundational condition of objectivity itself or any phenomenal unity, the unity of the subject is the unity of self-consciousness.' All cultural experience includes not merely a subjective but an intersubjective reference as well as a dimension of valuation. The sense of identification or alienation, appreciation or rejection, a sense of concern for what is significant for the self are pervasive ways of culture experience, which could be described as an experience of self-realization in some form. Not only can one not tell the dancer from the dance, but the spectator must forget and rediscover himself in the spectacle. The thinker incarnates himself in his thoughts, even the cook would be hurt if his cooking were not treated as representing him appropriately. Genuine participation in culture is a process in which 'the subject is realized, the object idealized'.

It is as an embodied consciousness that man becomes aware of nature as sensible forms in space and time and constructs them as a world with the categories of objectivity as quality and quantity, substance and action. At this level of the understanding of being as Nature, consciousness does not reveal its own subjectivity as a thing apart. Man is only a body, one object among others, subject to its innate drives and laws of motion, of action and reaction. It is only with reflective consciousness that the subjective-objective world of culture can be apprehended. If nature as a world of objects has its being for consciousness, culture has its being for a consciousness which is self-conscious. The apprehension of nature begins when we sense the pressure of an alien reality and it grows into the idea of a regular and invariant order of being constituted by causally operative substances and forces underlying the changing appearances of qualities and quantities in sense perception. The awareness of culture begins with the discrimination of the ideal and the actual, of what is appropriate to the self or authentic and what is merely given or appears forced upon the self. It is the awareness of an ideal order of being which constitutes a worthy end or goal of man's authentic seeking. The ideal is not given or importunate like the actual, limiting human freedom, but is only glimpsed as a possibility though it has its own inner urgency which constitutes the awakening of true freedom since freedom lies in the voluntary choice of ends worthy of realization. Where the bodily instincts are accepted at their face value and reality treated only as means to further instinctive drives, we have only a state of nature. If egoism and instincts are totally uninhibited, we would not have the cooperation necessary for a civil society and in its absence no education, tradition or

culture. If the Hobbesian man with the help of a calculating reason were to build a civil society in which the maximum satisfaction of the instincts were attempted by utilizing natural resources through positive science and technology, we would have a civilization which being amoral could not be called cultured in any traditionally acceptable sense. If this were considered merely semantic, there is still a deeper question—is such a society or civilization really possible? Love and self-sacrifice, trust and loyalty, compassion and justice, and a disinterested search for knowledge are necessarily required elements in any society and civilization. Even Hobbes had to premise the sanctity of promise and the recognition of mutual interest in a contractual obligation. His civil society has place for virtue as well as for science. The fact is that egoism and hedonism are merely philosophical assumptions seeking to reduce man's social and moral life to a naturalistic psychology. The egoistic-social character of man, his *ungesellige Geselligkeit*, cannot be understood without reference to his inherent capacity to discriminate right from wrong, sense of duty, higher emotions like love, the use of symbolism and the quest for knowledge. As a moral being, man distinguishes his duty from his interests. In his feelings he distinguishes the higher from the lower emotions. As an intellectual being, he distinguishes appearance from reality, error from truth. The discrimination of value from disvalue in different dimensions is, thus, the essential feature of man as a conscious being and is the source of cultural life. Culture is not like Nature, an order of facts and principles indifferent to human consciousness. It is the social expression of a value-seeking, symbolically expressive human self-consciousness. The discriminative-critical character of the consciousness makes its seeking dialectical. At the same time, to seek a value is to seek to progress in an infinite direction, for it is the nature of value to be a standard of perfection which judges all attainments to fall short of the ideal. Thus, whereas Nature has no history, culture as value-seeking is inherently historical as it is bound up with a social and symbolic tradition within which its dialectical and 'developmental' process operates.¹²

Value implies seeking, choosing, approving. Something is valued because it is desired and its desiring rationally approved. Owing to this duality, no purely naturalistic or purely rationalistic theory of value can be fair to it. Value is neither a mere desire-construct like interest, which is relative to the subject and circumstances, nor a timelessly self-subsistent order of intelligible forms independent of any subject. Desire and feeling give an immediate intimation of value in terms of some particular object or experience while critical reason indicates the imperfect or even erroneous character of such an identification of value. Value-seeking, thus, tends to be a dialectical

and progressive process where ideally one moves towards a perfect and infinite realization in which the immediacy of feeling and cognitive certitude would be found together. Such a state would be the unity of being and knowledge, in which the self or consciousness realizes itself fully. 'Human nature exists at many levels, from the biological to the purely spiritual, seeking self-fulfilment at each level. Consequently the gamut of values extends from self-preservation to mystical communion. Since the lower realizations are only virtual (*aupādhika*), they contain an inherent urge for self-transcendence. From the lower realization of the self in terms of finite accidents (*upādhis*), to their complete transcendence in pure self-experience, the human seeking follows a process of dialectical evolution'.¹³

The dialectic is a self-critical tendency in human consciousness and as the matrix of enlightenment, is latent in empirical consciousness in which its actual finitude is juxtaposed to its notion and aspiration after infinity. It is not necessarily a purely logical dialectic of contradictions nor even a 'spiritual' dialectic of distincts or complementaries. Nor is it a historical dialectic working ideally to ensure a unique, necessary or predictable course of actual happenings or progressing through natural or social conflicts. Nor indeed is there any reason to suppose that there is a unique and perfect dialectical system given eternally in the Absolute Idea for the Idea being a succession of finite determinations is endlessly dialectical and cannot represent the Absolute as a completed system much less reflect self-consciousness as a concrete universal. No logical idea can represent the Absolute which can only be intuited as an imponderable horizon in self-consciousness or value-consciousness. It is this imponderable intuition of the self as value that is the driving force of all cultural praxis or *sādhana*. If there is a pattern laid up in heaven, no adequate account could be given of it as a system of principles because all such accounts would lack logical inevitability and remain open to criticism in terms of a Mādhyamika-like dialectic. The archetypes could, of course, be ritually symbolized or imitated. There would be alternative systems and none would, in any case, be able to uniquely represent the richness and variation of the experiential pilgrimage of the spirit as an actual self-consciousness. Man learns by experience and self-criticism and the dialectic of value-seeking is the dialectic of self-transfiguration through the interaction of vision and praxis. It implies not merely a process within a plane of consciousness but a change in the plane of consciousness.

It was mentioned before that value is neither a merely subjective non-cognitive mental attitude nor a purely objective logical idea. It is a mode of self-consciousness which critically seeks authenticity. Now consciousness is

the presupposition of all discourse but its essence is self-consciousness, and self-consciousness is the original as well as the paradigmatic case of value-experience. 'All things are loved for the sake of the self' and the self is universally present and undeniable, yet the self is erroneously confused with what it is not. The empirical self is a paradoxical union of the self and the non-self, the subject and the object, in a self-consciousness which is actual in a temporal world of objects and other selves and yet constantly pulled inwards by its own eternal and pure nature. 'Compounded of mutually superimposed subjectivity and objectivity, human self-consciousness is subjected to contradictory pulls. The true self or authentic being is obscured by inauthentic images and its autonomy is lost in the heteronomy belonging to the representations of Nature. The struggle of authentic and inauthentic self-awareness is, thus, perpetual in human life.'¹⁴ This struggle constitutes the core of the dialectic of value-seeking at all levels, individual, social and cultural, though culture being the tradition of value-seeking enshrined in symbols has also the role of guiding men individually and collectively by communicating the vision of the ideal and the tested ways of *praxis*. All *praxis* is designed to subordinate or sacrifice the lower to the higher so that the object to be used by the ego and the ego itself are offered to and become the vehicle of a higher consciousness. In so far as the lower is used to reveal the higher, it may be said to assume the character of a symbol. To seize this immediate symbolism and give it an external form within a process of communication, constitutes the birth of a tradition which subsists and grows by way of an educational process. The primary origins of a cultural tradition, thus, lie in the revelation or discovery of new meanings in phenomena given at various levels, a process which begins in individual psyche but enters social tradition creatively as a symbol.

From human self-consciousness springs the dialectical quest of value, which is symbolically expressed and communicated within an inter-subjective world and as an educational tradition constitutes culture. But although conceptually autonomous, culture is, in fact, found embedded in the life of historical communities in space and time even as consciousness is found actualized, and individuated by human bodies and educatively formed by a social tradition. The dim spark of consciousness manifested through the human body needs to be nurtured by tradition, speaking through signs and words even as the body needs to be nourished and trained through personal care and food. One may thus speak of the social body of a culture and call culturally animated societies as civilizations. The social body enables the survival of men and traditions, culture gives it identity and character.

Civilization is sometimes understood as a developed state of culture,

sometimes as a culture with emphasis on its material values. It may, however, be considered as the order of means which give power to a society. A society is recognized by institutionalized cooperation, and civilization by collective achievements of quality and power. Culture, as a pervasive moral order binds society and civilization and gives them a characteristic identity and direction. Whether it is the order of immediate-affective relations as in a family or the cooperative and *quid pro quo* relations of the techno-economic order, or the legal-political order backed by force, the moral order is pervasive. Without an immediately felt but objectively recognized, coherent order of duties and obligations no society or civilization can even survive, let alone develop. This moral order presupposes the formulation of the vision of the good into a path of *praxis* leading up to it. Alternatively, one could speak of the institutional structure of a society or civilization as based on a system of values and the values themselves as preferred ends and means resting on faith and knowledge. It is as moral faith which mediates between vision and *praxis* that culture animates society and civilization. The three, however, are only conceptually distinct as these cannot be found separately in reality. Cultures, in short, are moral traditions interpreting the vision of the good in characteristically diverse ways owing to their being embedded in historical societies or civilization.

At this point it would be useful to examine the meaning of the historicity of civilization, especially in view of the fact that its linear evolutionist conception has almost monopolized its historiography. This conception not only appeals to what may be called the moral influence or intellectual prestige of the theory of natural evolution which it seeks to extend to human society, but also assumes the notion of human progress since it developed in the eighteenth century. It assumes that owing to the growth of scientific rationality, human civilization has been improving over the ages. Anthropology and prehistoric archaeology have sought to evidence it for the prehistoric past while the historians of science, technology and even philosophy have sought to trace the progress of knowledge and civilization in the historic ages.

In a way, such a view implies an essentially historic view of human knowledge and at the same time contradicts itself by appealing to a future which cannot be known in principle. It assumes that ideally science or philosophy has a universal and timeless truth which may be discovered piecemeal in different places and ages but in which, if the accidental errors are excluded, we would reach a fragmentary kernel of what may be called perennial scientific and philosophical truth. Thus, when the modern scientist or philosopher reviews past science or philosophy, he either discovers what

he *already knows* though in some strange form or as a tissue of confusion and errors. The concept of linear evolution thus could be seen as a way of reconciling the corrigibility of science with its ideally timeless truth.

Such a view, however, has an obvious limitation. No one can say what the ideally true science or philosophy is like because future discoveries of science are unpredictable. Knowledge is structured as a system of statements, the truth of statements is not independent of the system, and it is difficult to argue that we have reached a unique systematization in which only specific gaps, doubts or errors need to be removed. The attempt to correct results tends to precipitate in due course the revision of the system itself and the truth of a system is not of the same sort as the truth of its elements. Systems often spring from presuppositions and hypotheses which are not directly or easily verifiable or falsifiable. The history of Euclidean Geometry provides a striking example. The concept of paradigm-change in the historiography of science too, despite controversy, retains undeniable relevance.

The history of philosophy illustrates the principle of relativity or historicity of truth even more clearly. Different fundamental insights in philosophy have produced systematic development in different directions continuing over long ages, and Platonism and Aristotelianism, Vedanta, Nyaya and Jainism are examples. These schools have developed through interaction with other schools within the changing challenges provided by the cultural context of different ages.

It, therefore, seems that the historian has no choice but to seek to relate beliefs and norms to the overall thrust of tradition and pressure of social change within which they have their origin and currency. There is no escape from seeking an integrated picture of science, philosophy and culture if each is to be understood within the concrete process of civilizational history.

It may, however, be argued that although the ideal science, philosophy or culture may always recede from us like the horizon, nevertheless we make a progressive, perhaps asymptotic approach towards it. As a result, in practice there is no option to regarding present science or philosophy as the standard point of reference for the understanding or evaluation of past science and philosophy. The generally accepted theory of historical evolution implies that human society and culture have not only been changing but progressing through the ages. And it has also been argued that this process of social evolution has been the result of growing science and technology. By the side of this may also be mentioned the view that a true sense of history has been lacking in India, possibly because Indian society has been stagnant owing to a slow change in science and technology. It has also been said that the development of rational science and philosophy itself was obstructed in

India by the prevailing obscurantism of mythical ways of thought, a condition which was supported by a social order where vested interests were protected by myth. Thus backward science and mythical ideology formed a vicious circle which hampered the development of reason as well as social progress.

One may begin to examine these views by focussing on the concept of history in the first instance. History may be said to be defined, not by its subject-matter but by its method. The world—which the historian studies is not accessible to him in any possible observation since it is irrevocably past and gone. He neither observes what is given to him in experience nor does he study merely possible classes of phenomena.¹⁵ He seeks to study the world as it appeared to men in the past. His method is to study the records of past experience and reflections. It is the surviving record of human thought and experience that constitutes the primary evidence for the historian. This evidence has an objective as well as a subjective dimension. It can hardly be regarded as the simple record of what was the case; it must also be seen as an expression of subjectivity, a record of human reaction.

While all past records are relevant to the historian, they remain primarily records of consciousness, not records of reality as Nature. What the historical method reconstructs is the constitution of a time-specific world-appearance and its correlative subjectivity. The method works from within outwards, i.e., from the expression of consciousness to a specific form of the self-conscious human world *sub specie temporis*. It is this interpreted and reconstructed content of past records which images what may be called historical reality. Historiography may thus be defined as the interpretative rediscovery of the form of consciousness which has left behind its own records. It would be obvious that by consciousness in this context I do not mean pure, absolute consciousness, nor the personal immediacy of the individual organism. Consciousness is taken here as a trans-personal content constituted in social time, consciousness as a mediated, social self-consciousness, as word and meaning, *saviśeṣa*, *sopādhika*, *śabdānuviddha-pratyayātmaka*, including *gaṇapratyaya*.¹⁶

Subjectivity, again, does not signify in this context the bias or prejudice of records but their being rooted in the subject, individual, social and universal, the three dimensions being interlocked in a specific temporal constitution. The historian's method of dealing with records is a complex one in which the strands of criticism, hermeneutic, phenomenology and dialectic are interwoven. It is critical in a multiple sense. It does not take the record at its face value but examines its credibility. It seeks to understand the meaning of the record and the voices within it. It seeks to place the meaning or intention within its multiple context, logical and social and

personal, where relevant. It seeks to apprehend the deeper forms exemplified in the meaning and it seeks to trace in them the working of a dual dialectic, the dialectic of ideas as well as the dialectic of social being. Thus the historian of Śaṅkarācārya could begin with the authenticity of the works ascribed to him and proceed to discover their meaning in which he must distinguish various traditional and non-traditional voices. The intellectual and social context of Śaṅkarā could be as relevant as the dialectical criticism and interaction of philosophical ideas. The place of Śaṅkara within the historically developing Indian tradition could be a part of the dialectic of historical being.

This account of historical methodology may be seen to be in broad consonance with what has been exemplified in characteristically diverse ways by such masters of cultural history as Bruckhardt. The question may be raised as to whether it is also in conformity with the practice of other kinds of histories and historians. The major form of historiography has been that of political events and institutions, to which, as is well known, the standard form was given by Ranke and others in the nineteenth century. Political history thus understood describes facts on the basis of actual records, the facts themselves consisting of actions and events arranged in chronological and causal order. With the increasing appreciation of the role of institutionalized life, such a history gives the impression that the sequence of causally determined political actions constitutes an objective, almost autonomous reality. The fact is that political events are unintelligible except within the context of interests, motifs and ideas of the actors, that is to say, except with reference to a world subsisting in consciousness. Political history simply enacts a drama rooted in social consciousness. Now this world of inner forces is not evidenced in the same manner in the archival records as the ostensible world of events which is directly intended. The certainties of critical history with reference to events tend to dissolve as soon as it enters the realm of motives and ideas. If in the search for objectivity the historians were simply to describe the observations of events recorded in the sources, they could not avoid producing a chronicle instead of history. The fact, however, is that the most empirical and objective of histories is forced by its very assumptions to seek for causal explanations and such explanations of human actions cannot be divorced from the understanding of the mind which is not accessible to empirical observation. If one were a consistent behaviourist, one would be condemned to be a trivial chronicler. To give a meaningful account of human actions one must link them with the minds of the actors and their minds are by definition beyond the empirical observation recorded by the original witnesses. Doubtless, the witnesses

claim to perceive behaviour along with motives, purposes and characters but these are not observations in the strict sense but rather complex inferences.

There are doubtless records of observations of natural facts, e.g., *Śatapatha Brāhmaṇa* speaks of the Pleiades being due east at the time of sunrise apparently during the vernal equinox. Such a record is relevant for dating the observation rather than for knowing about the revolutions of the heavens. It is the knowledge of astronomical science which helps one to understand and evaluate the recorded observation. The recorded observation is not a part of the present structure of astronomical science. Records of economic or demographic data similarly are evidence for the reconstructing of some specific human past. They are not data for the construction of a science of economics and demography. Social sciences, to the extent to which they are really scientific, cannot be derived from the fragmentary time-specific social data from the past. As real sciences they have to be based on repeatable observations of classes of recurrent phenomena.

The method of history, thus, is quite distinct from that of any science, empirical or formal and so is consequently its subject matter. The major *Pramāṇa* for the historian is verbal testimony and the major *Prameya* is the contextually intelligible meaning, *Āgamikārtha* as the content of *Itihāsa* was described by Abhinava Gupta. These meanings are, on the one hand, expressions or intentions of consciousness and, on the other, representations of ideational and life forms. Verbal communication reveals the subject from which it proceeds and the objective forms which it intends. It is a peculiar kind of effect in its first aspect, a sign or symbol created by consciousness. In its second aspect, its immediate object is a form or possibility but the same may also be referred to a perceived or imagined actuality. It should be obvious, then, that the causal factor in history not only operates through the human psyche but is also manifested through it to the historian. History here does not mean hypothetically conceived objective external events on the analogy of natural events. History here means what the historian discovers by delving in his evidence which is ultimately verbal testimony or dependent on it. Now verbal testimony is never an independent source of knowledge of natural reality or external events although it is the prime source of knowledge about human persons and minds. It is always the expression of beliefs and attitudes, but the psyche to which these belong is not an isolated atom or monad. It is a participant in a wider multi-streamed psychic universe. Its autonomy is plainly limited and its heteronomy undeniable, though the nature of the causally conditioning heteros is a matter of philosophical determination. Even if one adopts a naturalistic-realistic conception of the

world, it cannot be denied that one cannot *understand* human behaviour simply as a fully determinate and predictable function of the natural environment. The environment itself, or at least its impact, is modified by human action, the social environment is nothing but man writ large, human behaviour as intelligent and meaningful irreducible to simple physical and chemical activity. Man is a self-conscious being with a sense of freedom, and any deterministic reductionism which steps far beyond the magic circle of self-consciousness is bound to become irrelevant to historical understanding.

The historian's records, thus, are the documentary testimony of a temporally constituted social self-consciousness, his world is a world of meanings fashioned and ever renewed by human beliefs, attitudes and actions. The historian's world is no longer accessible to experience and his representation of it is wholly unverifiable. It is difficult for this representation to be independent of the beliefs and attitudes of the historian as a participant in his contemporary age, even though he cannot, as historian, take sides between true or false religions, or philosophies or sciences except that he can notice inconsistencies—logical, moral, aesthetic—or failures in action, or the inadequacies of means to ends within the world he studies. This attitude of objectivity is not uncommon among historians with respect to religion or philosophy nor among anthropologists with respect to archaic cultures. The situation today is undoubtedly different about science, but the situation is parallel to that of mediaeval historians firmly distinguishing between true and false religion. Pre-modern scholars or historians, indeed, did not make any radical distinction between natural science, metaphysics or theology. All of these were sciences in an increasing measure. The idea that not metaphysics or theology, but only empirical science of nature is truly science and that others are false or doubtful systems of beliefs, that empirical science alone constitutes positive knowledge and is a culture neutral but universal and evolutionary constant, would have found little support among them. Positive knowledge and practical skill have always been prized and cultivated but in the earlier ages they were prized within the bounds of a cultural ethos which looked beyond the merely earthy life of man to his heavenly destiny. Such, however, is the force of cultural ethos that the modern historian, even though he is not a scientist, feels it incumbent on him to endorse not merely the empirical truth of natural sciences but also an attitude of scepticism towards traditional beliefs. This is simply a consequence of the historian's acceptance of values which define modern culture, it is not relevant to his task as a historian pure and simple.

It may be said that the historian is necessarily rooted in contemporary

history, his reconstruction of the past bears the stamp of the present, that in a profound sense all history is contemporary history. As a result, history today is unavoidably 'scientific', just as mediaeval history was theological and archaic history mythical.

There is undoubtedly a trivial sense in which all history is contemporary since the activity of the historian belongs to his own time. The profound sense in which all history is contemporary rests on the historian's taking his presuppositions from the prevailing ethos of his age. Now while this is common, it is not necessary. The human tradition is never wholly monolithic or homogeneous, it always includes an element of self-criticism, a sense of its own inadequacy. The historian requires to be critically neutral towards his own age. To the extent he is prejudiced in favour of his own age, he fails to be a critical historian. A relativistic philosophy is part of the historian's methodology. All beliefs and values are relative to their concrete historical context. Indeed, their meaning is constituted by their context. The positivist seeks meaning in terms of verification. In the absence of verification, the critical historian defines the meaning of past notions, norms and values through contextual colligation.

It must be clarified here that this methodological relativism of history must be distinguished from historicist relativism which is not only deterministic but converts accidental collectivities into self-determining supra-individual spiritual entities. Historicism seems to presuppose an obscurantist metaphysics and to absolutize for each nation its own historical tradition. Although cultures and civilisations show a certain *Zusammenhang*, they also retain in some respects the aspect of the accidental formation of congeries. As a result, the internal consistency and autonomy of cultures is balanced not only by internal differentiation but by interaction with other cultures. Oriented towards an internal focus different cultures seem to be divided by semipermeable boundaries of communication, almost as if they were like the murals at Ajanta, continuously running panels within the larger frieze of a Universal human culture.

Since, up to a point, positive science and technology cross cultural boundaries more easily than many other cultural sub-systems, it is easy to think of them as universal. If one also thinks of them as 'basic', one could think of different cultures as variations corresponding to different phases of science and technology. This, however, is simplistic. It is true that verifiable empirical knowledge and obviously useful techniques discovered in one culture may be easily accepted in another in so far as they do not involve accepting any obviously necessary moral and metaphysical assumptions or change of social system. Thus certain astronomical observations of the

Babylonians passed on to the Greeks and the Indians, Indian numerals to the Arabs and the West, Chinese gun-powder to the rest of the world. Tool making techniques circulated in prehistoric times, and modern western science and technology are influencing the whole world today. But while directly verifiable and useful empirical results and techniques do not know cultural barriers since they belong to the level of common sense, sophisticated theories or theory-dependent technologies cannot be placed in the same class. While science and technology are commonly pursued in all civilisations, it seems that they acquire increasingly culture-specific forms as they develop into sophisticated theoretical systems or come to be based on them. In such developed forms science, technology, economy, the state and social ethos become increasingly interdependent. As such intercultural communication or transfer of developed science and technology is not easy. For example, as an empirically verifiable result the so-called Pythagorean Theorem was well known in ancient Egypt, Greece and India but its Euclidean proof and the underlying axiomatic system remained Greek. Similarly the difficulties in the transfer of modern Western technology to non-Western countries include a cultural dimension too. It seems arguable that although science and technology are found in all cultures they are not uniform or culture-neutral.

The relativism of the historian, thus, is neither subject to the deterministic and collectivistic monadism of the historicists nor to the absolutism which goes with scientism or theology. The historian does not make absolute judgement of truth or value. For him, *tout comprendre c'est tout pardonner*. He does not describe any unique series of external events as a geologist does. Nor is he a mere chronicler of datable events except as constituents of a psychic context. He seeks to understand the temporal revolutions of human subjectivity through the critical analysis of its recorded expressions. It is not the task of the historian to be the panegyrist of any past or present theory, ideology or social system. He must see each of these as elements functioning in a context which tends to assume the form of widening spheres of understanding. It would follow that the history of Indian science, philosophy and culture is not to be conceived as the 'prehistory' of modern science, philosophy and culture but as the history of the characteristic traditions of science, philosophy and culture belonging to and interacting within the Indian civilisation.

Against this stands the common view which regards history as a linear evolution of mankind and the task of the historian as offering causal explanations of its movements. Now it is well known that biological evolution is supposed to be the result of genetic mutation and the survival of the fittest

in the struggle for existence. It is not clear how this concept is to be transplanted to human history within which one cannot find any evolution of the human organism. The term 'evolution', thus, can only apply metaphorically to society or culture, i.e., to those characteristics of the human community which it progressively acquires through learning. Neither society or culture is an autonomous organism and no significant dynamic operates in them except through the action of individual agents and the force of tradition. In what sense can evolution apply in this context? The free and rational nature of man cannot be shown to have evolved in any objective sense. Attempts to prove this by referring to the myth-prone character of the primitive mind really beg the question and forget that it is the primitive man who laid the institutional and technological foundations of civilization. Myth was not confused philosophy or science but the symbolic expression of wisdom.

Turning to tradition, it can certainly be seen to be in a process of change, but in what significant sense can this process of change be called an evolution? Spencer tried to define the characteristics which define a process of social evolution. Max Weber and others too have sought to define such processes. The definitions point in brief to more rational organization as the mark of evolution but this rationality of means remains contingent on the assumption that the end of society is the maximization of effective individual choices and satisfactions, an assumption which only reflects a particular moral or rather amoral philosophy widely current in modern times.

Similarly, the idea of cultural evolution assumes that the values accepted in society have been gradually improving. For this not only must one know the ideal system of values but also how different approaches to it are to be evaluated. Both these are largely matters of faith. For evolutionist historians the values of modern culture are the most advanced. This notion derives from that of the superiority of European civilisation over the rest of the world which has been growing in the West since the eighteenth century assuming the forms of theories of progress, evolution and development. These ideas have indeed preceded detailed historiography on these very lines.

Since the concept of the linearity of history is bound up with that of evolution, it does not require a separate discussion. It has already been argued that evolution in natural history provides no support to the idea of evolution in human history. In the absence of any determination by natural factors, other types of justifications have been brought up in favour of the idea of historical evolution in human society. Many Christians have believed

that the Christian era of human history is qualitatively superior to the earlier era and even a historian like Toynbee once argued that the destiny of man is to be fulfilled by the development of Christianity. On this view it is divine Providence that determines human history, a view which is shared by many other religious faiths in different ways. The improvement of human nature is here attributed to the working of a supernatural Providence but the primary locus of this change is believed to be the individual soul. The reordering of society is held to proceed from the regeneration of the individual and the adoption of a revealed law. Since these views attribute human improvement to the unpredictable operations of divine grace and human freedom, they are quite different from evolutionist theories.

The most common theory of evolution today rests on the belief that the techno-economic substructure determines the form of society and that in turn conditions its culture. There is no unanimity on the forms, stages and processes through which this evolution takes place. Nor indeed is there any agreement on the precise nature and extent of determination. That available technology determines the means of production is undoubtedly true but it is also true that the existing structure of production determines the direction of technological effort. Similarly, economy, society, polity and culture function as mutually determining forces. There does not seem to be any single overall determinant working uniformly in the same direction. As a result, what can be seen in the constant process of social and cultural change is a crisscross pattern of growth and decline. Whether there is an overall pattern or direction remains a speculative matter. The historian knows too little about the life of man in time to be able to perceive any overall direction in history. It is only speculative philosophy or theology which can rise above the limitations of critical history and view time from the vantage point of eternity.

A more moderate and less deterministic view of evolution rests on the faith in human rationality. Man's rationality and freedom must mean that he should always seek to approach his goals by learning from experience and thus adopting more successful means. Discovering the laws of nature and using them to further his goals, man must develop an increasingly rational and effective tradition. The basic difficulty with this view is that it underplays not merely the irrationality of man but also the many-sided and dialectical nature of reason. The reason employed in natural and mathematical sciences is relevant only to the prediction and control of regular, quantifiable external phenomena. Bergson thought it misses the reality of time or consciousness. In any case, moral, aesthetic or spiritual reason cannot be reduced to it. The different dimensions of reason are not only distinct but

may appear in conflict. Besides, in any dimension reason seeks to find itself through an endlessly continuing process of negation of which the occasion is often dependent on reflection over experience or intuition. The dialectical character of reason arises from its functioning as concept, judgement and inference, in which discrimination or negation is inevitable. It is difficult to see how discursive reason can overcome its own essential one-sidedness, although more than one dialectic has been proposed for the purpose. That it is possible to reach a unique, pure, ideal dialectic in which the forms of all knowledge are gathered in a unity, even while each has its distinctness, could be acceptable only if the human mind had the omniscience of God and the omniscience of God had the form of human reason. The fact is that the dependence of discursive reason on language and external data precludes its being 'pure' in any significant sense. Its concepts arise from the comparison of empirical or intuitive data. Its basic rules are either linguistic and conventional or modelled on empirical phenomena apprehended in an abstract or one-sided way as forms or relational possibilities.

The historian of ideas does not discover any linear development or dialectical necessity in historically given scientific or philosophical systems. Ideas appear to be tied within cultures which remain partly isolated, partly interacting modes of socially actualized and symbolically expressed human self-consciousness in a process of temporal formation and transformation. Histories of science and philosophy remain integral aspects of the history of culture or cultures within a civilization. Such a history is unlikely to discover a linear course of development aspiring towards the present condition of the West. Its explanations have to be contextual, not merely causal. Its theme would be the traditionally structured beliefs and attitudes within a world of social action in specific ages. On account of the fragmentary nature of the available sources such a history is bound to be fragmentary and beset with uncertainties.

Such a history of Indian science, philosophy and culture would be focussed on the structure of scientific and philosophic ideas and cultural values within the broad sweep of Indian civilization. It could doubtless be integrated into a universal history of human civilization and such a history with a just perspective is yet to be written. It is not merely that there are few sufficiently detailed and authentic works or histories of the kind for non-Western civilization, but that the culture-historical perspective will have to be adapted to each tradition as has been attempted in a different way by Needham for China. For the Indian tradition each one of these terms—history, science, philosophy and culture—needs to be understood in an appropriate, relevant sense.

The Indian tradition has been characterized as ahistoric, lacking in historical sense, just as it has been accused of being deficient in scientific reason or rational philosophy. If these characterizations are correct, it would only show how severely limited those features must be which are being denied. The divisions of knowledge or the arts are not the same in all cultures, nor are they conceived in the same way. *Itihāsa* and *Purāṇa*, *Vidyā*, *Kalā* and *Śilpa*, *Jñāna* and *Vijñāna* and *Śāstra*, *Agama* and *Amnaya*, *Dharma*, *Karma*, *Vidhi* and *Samśkāra*, *Puruṣārtha* and *Sādhana*, etc., are some of the terms which articulate the Indian world-view and give it a conceptual structure. It is not possible to go into any details about this structure in this preliminary overview since it is really a structure resting on many substructures and developing over time. Nevertheless, one could see in the Indian tradition certain basic values and ideas underlying all the forms of thought and giving a certain unity and direction to its culture and mode of development. The central idea in the foundational age of the tradition viz., the Vedic age, was that of *Rta* or Cosmic law which joined man (*Puruṣa*), the world (*loka*) and the gods (*deva*) and was represented in *Yajña*. In the later Vedic age the concepts of *Brahman-Atman* and *Dharma-Karman* constituted the culmination of the earlier ideas. The highest science or *Parā vidyā* was conceived as *Brahmavidyā* or *Ātmavidyā*. Here eternal knowledge is intuitively realized within oneself as the perfection of being, liberating man from Delusion, Desire and Suffering. Lower sciences (*aparā vidyā*) are variously classified. The four-fold classification into *Trayi*, *Vārtā*, *Daṇḍanīti* and *Anvikṣikī* is well known. They are generally conceived as *śāstras* furthering some human value (*Puruṣārtha*). Each *śāstra* has its own characteristic *Pramāṇas* and *Prameyas*. *Vyākaraṇa*, *Mīmāṃsā* and *Nyāya* were preeminent sciences, Pāṇini's *Sūtras* attaining a well-nigh paradigmatic status. The development of the *śāstras* took place through commentaries and debates or *śāstrārthas*. The major sciences resting on empirical verification were astronomy and medicine. Their cosmological and 'anthropological' assumptions were drawn from the philosophical tradition. Philosophy was regarded as the highest kind of scientific knowledge, critical, systematic and liberating. It was above all the search for self-knowledge as the reflective recovery of what is eternally given within oneself.

The structure of sciences, thus, was conceived in three tiers which may be described as empirical (*dr̥ṣṭārthaka*) including *arthaśāstra*, *śilpaśāstra*, *cikitsa* and *jyotiṣśāstra*, formal and methodological, concerned with *pada*, *vakya* and *pramāṇa* including *śabdavidyā* and *hetuvidyā* or *Anvikṣikī*, and moral and spiritual including *dharmaśāstra* and *mokṣaśāstra* or *adhyātmavidyā*. The first tier is relevant to the pursuit of instrumental social values through

empirical-rational means (*pravṛtti*, *artha-kāma*, *Niti*). The second is useful for the pursuit of any knowledge and is a refinement of the intellectual faculties (*Vidyā*, *Parīṣkāra*). The third helps the search for transcendental, moral and spiritual values (*dharma*, *mokṣa*, *paramārtha*). If a scheme of values (*puruṣārthas*) underlay the division and hierarchy of the sciences (*vidyās*), a basic ontology lies behind the scheme of values. The duality of time and eternity and the foundational character of the latter, are commonly upheld in the Indian as in all traditional cultures. So also is the belief that there is a tradition of knowledge available to man which has its source in eternity. To this is added a characteristic insight in the Indian tradition which is that the eternal source of cosmic creation lies within the spirit of man which is essentially transcendental. It follows that while the empirical sciences giving power are useful for man's survival and comfort, their use needs to be guided by a rational and moral policy (*Niti*). Besides, for his highest end man needs worldly goods only minimally. What he needs is moral law and earnest reflection. Behind all this there is a basic assumption that there is an unfailing intuitive knowledge which can pierce through the veils of delusion which obscure the common life of man. This intuitive knowledge can be developed by a scientific technique designated *Yoga*. *Yoga* is the prime *sādhana* of *Parā vidyā*, the road to which lies through the *aparāvidyās* and *śāstras* linked to various *Puruṣārthas*.

'History or *Itihāsa* may be said to illustrate the moral and spiritual laws of action and change by the recollection of the past as preserved in the tradition. In reasoning (*nyāya*) particular instances (*drṣṭānta*) serve to illustrate the general rule (*vyāpti*). Reflection about human life and its vicissitudes necessarily involves a search for moral reasons and spiritual laws. *Itihāsa* furnishes empirical instances (*pratyakṣa-paridṛśyāmanah*) of the laws of action and experience which are made known by tradition (*āgamikārthah karmaphalasambandhasvabhāvah*). By connecting the particular empirical instances with ideal meanings revealed in tradition, *Itihāsa* accomplishes the impossible task of spanning the gulf between the empirical and the transcendent. *Itihāsa*, thus, is not a collection of stock tales but a storehouse of wisdom, of Veda. Its spiritual value is indeed superior to that of rational philosophy (*tarka*) and mere art (*kāvya*) since it inculcates the supreme wisdom of the vanity of ephemeral things.'¹⁷

To sum up, history is the critical reconstruction of the human past from records. This would not be disputed. Since the past cannot be observed nor statements about it verified, history cannot like psychology, economics or geography formulate any general laws nor can there be any predictions or retrodictions in history. What the historian reconstructs is not *completed*

within any unique series of public actions and events nor can he give adequate causal explanation of such events without speculative assumptions and interpolations. Even so the explanations must remain objectively untenable. To understand past actions and events the historian must delve into the ideas, attitudes and institutions of the age which structure its social self-consciousness. It is this temporally and socially structured mode of self-consciousness which may be called culture. The economically and politically organized fabric of collective life within which culture subsists as a symbolic tradition of values, may be called civilization. Culture and civilization may be said to be the moral and material orders of a society. The two together provide the context within which historical actions and events may be understood.

History is the contextual understanding of social actions, events and traditions. To the critical scientific method of examining records and inferring facts and factual relations from them, it must add the hermeneutic decoding of meanings, the phenomenological apprehension of cultural forms, and their dialectic, logical and social.

Despite interaction and semi-permeability, cultures remain characteristic configurations. How are these configurations to be identified? While the identity of a natural phenomenon is independent of its recognition, the same cannot be said of a cultural phenomenon. Water, for example, remained a compound even when it was mis-identified as an element for a long time. It cannot, however, be said that the holiness or divinity of the *Ganga* subsists outside of its recognition. The understanding of a natural object is completed by placing its perceptible features within a network of cause and effect. A cultural object, on the other hand, *qua* an item in the cultural world does not necessarily belong to any causal scheme. The holy *Ganga* thus belongs to a symbolic order representing moral and spiritual purification. Even where the causal power of a cultural object belonging to it by virtue of its natural aspect is relevant to its cultural status such as in the case of sacrificial fire, the object nevertheless is also imbued with social meaning and moral significance. In entering the cultural world, a natural object becomes a sign or symbol of meaning and purpose. A tractor, for example, is not merely a material thing but also a form of property, a sign of social status and, in a developing country, a symbol of progress.

Culture and cultural recognition are thus mutually relative. We cannot identify a cultural world without taking into account the matrix of awareness from which it proceeds, a matrix which is fashioned by history and subsists by way of a symbolic tradition. Identifying a culture, thus, is not like identifying a natural species on the basis of observation from without. It is rather

like the critical determination of the essential form and meaning of a poem or a philosophy, which is impossible without entering into the spirit of what is sought to be determined. The discovery of cultural identity thus requires a coordination of two enterprises, viz., researching and interpreting the meaning of tradition hermeneutically and thus viewing it from within, and viewing it in the larger context of universal history. The historian has to participate in the tradition without necessarily accepting it. He must view it *as if* he belonged to it. Only then will the tradition become accessible and yield its inner meaning and form and yet be objectified sufficiently to be placed within the context of history. The identification and understanding of a culture, thus, is possible in the main only through the critical and hermeneutic enquiry into its recorded, symbolic tradition and its reconstruction as a world of consciousness through historical empathy. It is not possible, merely or primarily, through empirical observation and ahistoric comparison of cultures assumed to be *given as such*, because as pointed out before, cultural forms are self-determinations of consciousness, not merely causal structures of meaning-free behavioural segments. A common objection to such an understanding of culture is that it would be largely bookish and unreal, the dead ideology of an elite lost in the past, not the living culture of the people today which can be described and analysed by the sophisticated methods of empirical research developed in the social sciences. However, the distinction between the folk and the elite, or the past and the present in a living civilization, has only a limited significance. Whether a civilization is alive depends on its continued creativity. So historical and empirical methods remain complementary, not exclusive.

From this essential ideality as well as historicity of cultural identity, it follows that empirically developed frameworks of categories within the modern sciences of culture cannot *ipso facto* be universal because even when comparative they presuppose the characteristic *Weltanschauung* of modern culture and tend to misinterpret myth and ritual as well as traditional social ethics, religion and wisdom. It has been argued on the other side that if such a universal framework were to be rejected the unity of the discipline studying culture will break down as also the possibility of intercultural scientific collaboration. These objections, however, are superficial. An analogy from the study of languages will clarify the truth. Different languages have different structures and use different sets of sounds. What is more, each language seems to analyse the world of experience differently. All this certainly makes communication from one language to another more difficult than communication within the same language. Nevertheless, it does not make languages wholly opaque to other languages.

The basic determinants of identity in all cultures have to be sought in their system of values and symbols, 'system' being used loosely to cover the evidence in parts of any kind of congeries or assortment. Religion and social ethics constitute the primary value system while language, ritual and art illustrate the symbolic systems; art, in fact, both realizing as well as symbolizing value.

Cultural identity in this sense tends to be circumscribed by the barriers of communication. The Arabs, for example, had no difficulty in learning science from the Greeks and Hindus, but there was an obvious barrier as far as communication in the sphere of religion was concerned. It is easy to multiply such examples. The contact of India with the West since the nineteenth century is itself illustrative of the difference in communication between different levels of culture. In fact, the awareness of Indian culture in the modern sense arose from the encounter. Different approaches to the discovery and exposition of Indian culture arose naturally and the present crisis of cultural identity in India may itself be traced to the continued effort to distinguish the essential from the inessential in the cultural tradition so that it may be understood as a creative continuation with contemporary relevance rather than as a dead burden on its way to the scrap heap of time.

If we think of culture as characterized by its values and area of communication, it would seem at first sight difficult to discover the unity of Indian culture in any distinctive sense. Since cultures like human beings show generic similarities, it is obvious that if we think of Indian culture with sufficient abstractness we would be universalizing it. On the other hand, in individualizing our characterization we must not forget that no culture with a continental spread and a long history can be homogeneous or monolithic. Thus the individuality of Indian culture must be so interpreted as not to militate against the universality of human nature and value-seeking. At the same time, the unity of Indian culture has to be interpreted with sufficient catholicity to include numerous communities, regions and epochs which have historically entered into its making. This search for the cultural identity of India, individual but aspiring after universality, one but inclusive of differences, continuous but developing, arises from the awareness of India's historic traditions. It should not be confused with the search for national integration at the political level. While it is true that the historical boundaries of Indian culture and civilization have been variable, they could never be identified with the political boundaries of any given age.

Reference was made above to religious and moral values as constituting the fundamental values of culture. From this it would seem that since Indian civilization is obviously multireligious, we can not really speak of a

unified culture in India. This, however, is not the case because the spiritual tradition of India accepts the validity of alternative religious systems, *dharma-samavāya* as the greatest ruler of India expressed it. The confusion would perhaps be removed if we were to substitute the phrase 'religious and moral values' by 'spiritual values'. Traditionally the mystic or the saint with personal realization has been given the highest respect in India. Seeking spiritual realization, called *sāadhanā* or *Yoga*, has been held to be the highest kind of value-seeking, *Sāadhanā* implies the dedicated and disinterested performance of one's duties whatever it might be so that we may move forward towards self-realization. The stories of Dharmavyādha and Tulādhāra illustrate how a hunter or merchant could be engaged in spiritual advancement just as much as a learned Brāhmaṇa or ascetic. The legends of Bodhisattva striving after Enlightenment in all stations of life illustrate the same universality of *sāadhanā* and show that it transcends the distinction of sacred and secular as well as the bounds of dogmatic religion. If *dharma* be the traditional counterpart of the notion of 'culture', the deepest character of Indian culture could be indicated by quoting *ayam tu paramo dharmo yad yogenātmadarśanam*, i.e., the highest ideal is to seek self-realization through *yoga*. And we could not seek a better or more inclusive definition of *yoga* than what the *Gītā* offers, viz., *yogah karmasu-kauśalam*, i.e., *yoga* is excellence in work. It may be added that such excellence is traditionally held to require disinterestedness as well as absorption. This subjective modality is as essential to *yoga* or *sāadhanā* as work itself. In fact, differentiation between them and overemphasis on one at the expense of the other and then again seeking to reunite them, have led to a dialectical development of alternative modes of spiritual life. This dialectic of *sāadhanā* is indeed the innermost dialectic of Indian culture. We can thus see the Vedic age as one of emphasis on work followed by a long period of the dominance of gnostic negation—*Jñāna* or *Mukti*—and attempts at synthesizing the two ideals of *Pravṛtti* and *Nivṛtti*. The preeminence of *Bhakti* in the middle ages saw the emergence of a new kind of subjectivity in spiritual life just as the nineteenth and twentieth centuries have again sought to rediscover the emphasis on work which the Vedas and the *Gītā* reveal.

The foregoing reflections may be summed up in a few simple propositions so as to facilitate discussion. Cultural identity can be discovered only from within a cultural consciousness through its historical tradition in which we need to critically participate even as we seek to be critical observers. The framework for identity will also have to recapitulate the articulation of cultural self-consciousness. It would be necessary at the same time to have a sense or glimpse of the imponderable vision and *sāadhanā* which lie behind

and above its ideal form. So culture may be described as an order of values, which derives from transcendental wisdom and its *praxis* and thus aspires after universality but is actually limited by manifesting *upādhis*, historic conditions and the barriers of communication. The communication relevant in this context is not the communication of mere facts or positive knowledge or value-neutral forms. Real cultural communication implies the communication of value as value. This will not necessarily lead to an acceptance of uniform values but will certainly lead to the acceptance of difference and richer harmony. The spiritual history of India is an illustration of this process. The social ethos which corresponded to this spirituality oriented but multireligious value-pluralism, was naturally one of tolerance and co-existence where different communities with their different traditions were not required to enter any uniform order. This is the social implication of the doctrines of *Ahimsā* and *Sva-dharma*. We have, again, to note particularly that cultural identity is not a static but a developing thing and that the most important factors influencing it are the inner dialectic of the spiritual quest of the culture and its dialogue with other cultures. I may add that the value-pluralism, which I have mentioned, is only the acceptance of a plurality of interpreting spiritual truth in conceptual or practical terms. Value in itself remains singular being nothing but the spirit.

Cultures, however, as mentioned before are necessarily embedded in societies organized for survival and adaptation. This combination of the order of ideal values with the actual order of social organization and all its purposes and pursuits, ideal as well as empirical, has sometimes been called civilization. Civilizations, in this sense, tend to be more universal with respect to their science and technologies than with respect to their values. Up to a point in her history India's civilization constantly absorbed influences creatively from her contacts with other civilizations and remained progressive or alive, but this process apparently slowed down as is apparent from *Al-beruni* already in the eleventh century. This tended to create an imbalance between spiritual creativity and the institutional life of the civilization with the result that by the nineteenth-century Indian culture seemed to find its identity in terms of timeworn stereotypes rather than in terms of the imponderable archetypal creativity underlying them, a confusion which the Renaissance and the Reformation of that century sought to remove through a dialogue with the past as well as with the culture of the West; a task complicated by considerations of politics or fanaticism.

To sum up, I would like to recall that 'culture' refers to a family of meanings which are expressed differently in different languages and cultures. Generally, these meanings include the ideas of value, form or order,

and tradition. In the light of the universal tradition of wisdom, value is ultimately the spiritual principle in man and the cosmos. Though 'eternal' it is manifested under limitations as a particular tradition of wisdom at the *right* time, of which the logic is inscrutable to the human mind. It is wisdom that provides the moral justification of the social order and gives to tradition the aspect of truth rather than of mere convention. Traditionally, thus, culture is not mere social convention, nor the mere product of natural or accidental causes. Modern sciences of culture tend to look upon it primarily as a structured social fact which may be understood and explained on scientific principles. Their principal achievement may be summarized as the idea of the social and historical relativity of cultural forms especially as brought out in the sociology of mind. A similar achievement stands to the credit of social history mainly inspired by Marxian ideology. On the other hand, the sociology of culture is asymmetric between science and religion, which only shows its modernist bias. Similarly the idea of unilinear evolution in history reflects an ethno-centric and ideological bias. The universal culture of man is not constituted simply by science and humanism but even more deeply by spiritual wisdom without which man would not be a moral being and humanism will prove a mirage.

I would like to close by quoting a famous verse:

*Śrutayo vibhinnāḥ smṛtayo vibhinnāḥ
Naiko munir yasya mataṃ na bhinnam /
Dharmasya tattvam nihitaṃ guhāyām
Mahājano yena gataḥ sā panthāḥ //*

NOTES AND REFERENCES

1. On the meaning of 'tradition'—Alwyn Moore and R.P. Coomaraswamy (eds), *Selected Letters of Coomaraswamy*, pp. 9, 45; Rene Guenon, *Hindu Doctrines* (Delhi, 1993), pp. 87ff; G.C. Pande, *Meaning and Process of Culture* (2nd ed.).
2. G.C. Pande, *An Approach to Indian Culture and Civilization*, pp. 21–22; G.C. Pande, *Bhāratiya Paramparā Ke Mula Svāra* (2nd ed.); G.C. Pande, *Foundations of Indian Culture*.
3. Cf. Manu, 2. 27–28; *bhāvanā* for *adhyātmaguṇās* or *sādhāraṇa-dharmas*.
4. This corresponds to *dharma* as *vidhi*.
5. This is *pāramparya*—Manu, 2.18 *Yasmin deśe ya ācāraḥ pāramparya-kramāgataḥ*; cf. BG.3. *Evaṃ paramparā prāptaṃ imaṃ rājarṣayo viduḥ*.
6. Cf. Ralph Linton, *Culture and Mental Disorder* (1956), pp. 5–6, where society is described as an organized group of individuals while culture is described as a group of common ideas, habits and emotional responses. The distinction has also been made as a distinction of normative and symbolic orders, cf. White, *Science of Culture*. For Kroeber, society and culture are counterparts 'like the two faces of paper'—*Anthropology*, p. 267.

7. Cf. G.C. Pande, *Mūhya-mīmāṃsā*.
8. Tylor, *Anthropology*.
9. Cf. A.R. Radcliffe-Brown, *A Natural Science of Society*, p. 3, 'a theoretical science of human society is possible, and there can be only one such science'.
10. Kroeber and Kluckhohn, *Culture: A Critical Review of Concepts and Definitions* (1942).
11. Durkheim, but is not such a reality, a *tertium quid* between mind and matter?
12. G.C. Pande, *An Approach to Indian Culture and Civilization*, p. 11.
13. Ibid., *Meaning and Process of Culture*, p. 1.
14. Paraphrases Śaṅkara, see G.C. Pande, *An Approach to Indian Culture and Civilization*.
15. Cf. G.C. Pande, *Itihāsa-svarūpa evaṃ siddhānta* (RGHA, Jaipur, 3rd ed.), pp. 183ff.
16. Ibid., *Meaning and Process of Culture as Philosophy of History* (2nd ed.), p. 48.
17. G.C. Pande, *An Approach to Indian Culture and Civilization*, pp. 130–31.

Significance of the Veda in the Context of Indian Religion and Spirituality

KIREET JOSHI

I

The four Vedas (*R̥g Veda*, *Yajur Veda*, *Sāma Veda* and *Atharva Veda*) are *saṃhitās*, collections or compilations of selections made by Veda Vyāsa. There was evidently at that time a larger body of compositions, and since they spoke of the old and new Ṛṣis¹ and of 'fathers' (pitarah), it may safely be inferred that there was at that time a tradition of generations of Ṛṣis. Presumably there was a pre-Vedic tradition too, since the Vedic compositions included in the four Vedas indicate a high level of development of poetic quality and spiritual experience, which can come about only through a long period of growth. It is difficult, however, to arrive at any conclusive determination of the dates of the Vedic or the pre-Vedic age, since there are varying opinions, and even conservative estimates vary between 500 BC and 1500 BC.²

The name that was found by the Vedic Ṛṣis for their expressive words and hymns was *Mantra*. According to the Vedic theory, the spirit of creation framed all the movements of the world by *chhandas*, fixed rhythms of the formative word. The metrical movements of the Vedic *mantras* reflect these cosmic rhythms as powers of balanced harmonies maintained by a system of subtle recurrences. *Mantra* is poetic speech which combines three highest intensities, a highest intensity of rhythmic movement, a highest intensity of interwoven verbal form and thought-substance, and a highest intensity of the soul's vision of truth. *Mantra* is that rhythmic speech, which as the Veda puts

it, rises at once from the heart of the seer and from the distant home of the Truth. The Vedic poet is conscious of his poetic activity; he is consciously engaged in the process of the Yoga of Works and the Yoga of Knowledge, and, in this process, he goes beyond mere intellectual illuminativeness and discovers that more intense illumination of speech, that inspired word and supreme inevitable utterance, in which there meets the unity of a divine rhythmic movement with a depth of sense and a power of infinite suggestion welling up directly from the fountain-heads of the spirit. The resultant Vedic poetry is seen as an epic chant of the spirit, its struggle and delight of ascent and victory, the secret of which is contained in self-consecration and surrender of the finite to the infinite, *Yajña*, where knowledge, action and love meet and become one.

The Vedic poetry is mystic and symbolic, and since the poets of the Veda had a mentality different from ours, their use of images is of a peculiar kind and an antique cast of vision gives a strange outline to their substance. In their method, a fixed system of outward images is used as the body of the poetry, while freedom is often taken to pass their first limits, to treat them only as initial suggestions and transmute subtly or even cast them aside or subdue into a secondary strain or carry them out of themselves so that the translucent veil they offer to our minds lifts from or passes into the open revelation.

In the eyes of the *Ṛsis*, the physical and the psychical worlds were a manifestation and a twofold and diverse and yet connected and similar figure of cosmic godheads, the inner and outer life of man a divine commerce with the gods, and behind it was the one Spirit or Being of which the gods were names and personalities and powers, *ekam sat viprā bahudhā vadanti*.³ These godheads were not only masters of the physical Nature but they were at the same time inward divine powers. Simultaneously, they were states and energies born in our psychic being. Godheads, *devas*, are declared to be the guardians of truth and immortality, the children of the Infinite, and each of them to be in his origin and his last reality the supreme Spirit putting in front one of his aspects. In the Vedic vision, the life of man was a thing of mixed truth and falsehood, a movement from mortality to immortality, from mixed light and darkness to the splendour of a divine Truth whose home is above in the Infinite but which can be built up here in man's soul and life. This building up the home of Truth here implies a journey and a battle between the children of Light and the sons of Night, a getting of treasure, of the wealth, the booty given by the gods to the human warrior, and a journey and a sacrifice. The Vedic poets spoke of these things in a fixed system of images taken from Nature and from the surrounding

life of the warlike, pastoral and agricultural Aryan peoples. And these images centred round the cult of Fire and the worship of the powers of living Nature and the institution of sacrifice. The Vedic poets used for their expression a fixed and yet variable body of other images and a glowing web of myth and parable which expressed to the initiates a certain order of psychic experience and actual realities.

II

Yaska has spoken of several schools of interpretation of the Vedas. He has declared that there is a triple knowledge and therefore a triple meaning of the Vedic hymns, a sacrificial or ritualistic knowledge, a knowledge of the gods and finally a spiritual knowledge. He has also said that the last is the true sense and when one gets it the others drop or are cut away. According to him, 'the Ṛṣis saw the Truth, the true law of things, directly by an inner vision'. He also said that 'the true sense of the Vedas can be recovered directly by meditation and *tapasyā*'. We also find that the Vedic Ṛṣis themselves believe that their *mantras* contain a secret knowledge and that the words of the Veda could only be known in their true meaning by one who was himself a seer or mystic; from others the verses withhold their knowledge. For example, in *RV* IV.3.16, the Ṛṣi describes himself as one illumined expressing through his thought and speech words of guidance, 'secret words'—*ninyā vacāṃsi*—'seer wisdoms that utter their inner meaning to the seer'—*kāvyāni kavaye nivacanā*.⁴

The tradition of mystic elements in the Vedas has remained alive throughout the ages, and it is this tradition which is seen as a source of Indian civilization, its religion, its philosophy, its culture.

It is, however, true that there was an external aspect of the Vedic religion and this aspect took its foundation on the mind of the physical man and provided means, symbols, rites, figures which were drawn from the most external things, such as heaven and earth, sun and moon and stars, dawn and day and night and rain, and wind and storm, oceans and rivers and forests, and of the circumstances of the force of the vast and mysterious surrounding life. But even on the external side, the Vedic religion spoke of a highest Truth, Right, Law of which the gods were the guardians, of the necessity of a true knowledge and the larger inner living according to this Truth and Right, and home of immortality to which the soul of man could ascend by the power of truth and of right being. In addition, the Vedic religion provided sufficient ground to draw even the common people in their

ethical nature and to turn them towards some initial developments of their psychic being, and to conceive the idea of a knowledge and truth other than that of the physical life and to admit even a first conception of some greater spiritual Reality.

But the deeper and esoteric meaning of the Veda was reserved for the initiates, for those who were ready to understand and practise the inner sense. It was the inner meaning, it was the highest psychic and spiritual truth concealed by the outer sense, that gave to the Vedic hymns the name by which they are still known, the Veda, the Book of Knowledge. Only in the light of this esoteric sense can we understand the full flowering of the Vedic religion in the Upaniṣads and in the long later development of Indian spiritual seeking and experience.

The inner Vedic religion attributes psychic significance to the godheads in the cosmos. It conceives of a hierarchical order of worlds, and an ascending stair of planes of being in the universe, *bhur*, *bhuvah*, *swar*. Truth and Right (*satyam* and *ritam*), which have their home in the highest world of *swar*, sustain and govern all the levels of Nature. They are one in essence but they take different forms in different levels of existence. For instance, there is in the Veda the series of the outer physical light, another higher and inner light which is a vehicle of the mental, vital and psychic consciousness, and a highest inmost light of spiritual illumination. Sūrya, the Sun-god, was the lord of the physical Sun, but he is at the same time the giver of the rays of Knowledge which illumines the mind, and he is also the soul of energy and the body of spiritual illumination.

All the Vedic godheads have an outer but also an inner and inmost foundation, their known and their secret Names. All of them have various powers of a highest reality, *ekam sat*, *tat satyam*, *tad ekam*. Each of these gods is in himself a complete and separate cosmic personality of the one Existence. And in their combination of powers they form the complete universal power, the cosmic whole. Each again, apart from his special function, is one godhead with the others. Each holds in himself the universal divinity, each god is all the other gods. This complex aspect of the Vedic teaching and worship has been given by the European scholar the title of henotheism. Beyond, there is, according to the Vedas, triple Infinite, and in this Infinite, the godheads put on their highest nature and are Names of the one nameless Ineffable.

This teaching was applied to the inner life of man, and this application may be regarded as its greatest power. Power of the godheads can be built, according to the Vedic teaching, within man, and affirmation of these powers leads to the conversion of human nature into universality of divine nature.

The gods are the guardians and increasers of the Truth, the powers of the Immortal, the sons of the Infinite Mother, *Aditi*. Man arrives at immortality by calling the gods into himself by means of a connecting sacrifice, by surrender. This leads to the breaking of the limitations not only of his physical self but also of his mental and his ordinary psychic nature. The Veda describes various experiences which indicate a profound psychological and psychic discipline leading to the highest spiritual realisation of divine status. This discipline contains the nucleus of the later Indian Yoga, the fundamental idea of which was that of the journey from the unreal to the real, from darkness to light, from death to immortality. This Vedic *Ṛṣis* speak of this as *ritasya panthā*, the path of the Truth. In one of the vivid descriptions of the spiritual realisation, Vāmadeva records: 'Vanished the darkness, shaken in its foundation; heaven shone out; upward rose the light of the divine Dawn; the sun entered the vast fields beholding the straight things and the crooked in mortals. Thereafter indeed they awoke and saw utterly; then indeed they held in them a bliss that is enjoyed in heaven, *ratnam dhārayanta dyubhaktam*. Let all the gods be in all our humans, let there be the truth of our thought, O Mitra, O Varuṇa'.⁵

This is similar to another experience described by Parashara Shaktya, who declares: 'Our fathers broke open the firm and strong places by their words, yea, the Angirasas broke open the hill by their cry; they made in us the path to the great heaven; they found the Day and Swar and vision and the Luminous Cows', *chakrur divo brhato gātum asme, ahaḥ svar vividuḥ ketum usrāh*.⁶ He declares again: 'They who enter into all things that bear right fruit formed a path towards the immortality; earth stood wide for them by the greatness by the Great Ones, the Mother *Aditi*, with her sons came for the upholding'.⁷

These and other statements give us the clue of what the Vedic *Ṛṣis* meant by immortality. When the physical being is visited by the greatness of the infinite planes above and by the power of the great godheads who reign on those planes breaks its limits, opens out to the Light and is upheld in its new wideness by the infinite Consciousness, Mother *Aditi*, and her sons, the divine powers of the supreme Deva—then one realises immortality.

Veda makes a distinction between the state of Knowledge and the state of Ignorance (*cittim acittim cinavad vi vidvān*), and discovers the means by which ignorance can be overcome. Upholding the thought of the truth in all the principles of our being, the diffusion of Truth in all parts of our being, and the birth of activity of all the godheads—this is the quintessence of the means of attaining Knowledge, which results in immortality.⁸

We find the most characteristic ideas of Indian spirituality in their seed in the Veda though not in their full expansion. There is, first, the idea of the one Existence,⁹ supra-cosmic, beyond the individual and universe. There is also the idea of one god who presents to us various forms, names, powers, personalities of his godhead. There is, thirdly, the distinction between the Knowledge and Ignorance, the greater truth of an immortal life opposed to the much falsehood and mortal existence. Fourthly, there is the conception of the discipline of an inward growth of man from the physical through the psychic to the spiritual existence. Finally, there is the idea and experience of the conquest of death, the secret of immortality. Throughout its long and uninterrupted history of the Vedic tradition, these ideas have remained constant up to the present day.

III

The Vedic beginning was a high beginning, and it was secured in its results by a larger sublime efflorescence. This is what we find in Upaniṣads, which have always been recognised in India as the crown and end of the Veda, Vedānta. While the Brāhmaṇas¹⁰ concentrated on the Vedic rituals, the Upaniṣads¹¹ renewed the Vedic truth by extricating it from its cryptic symbols and casting it into a highest and most direct and powerful language of intuition and experience. Indeed, this language was not the thing of the intellect, but still the intellect could take hold of its form, translate into its own more abstract terms and convert into a starting-point for an ever-widening and deepening philosophic speculation and the reason's long search after the Truth.

Upaniṣads are records of deepest spiritual experience, and documents of revelatory and intuitive philosophy of an inexhaustible light, power and largeness. Whether written in verse or cadenced prose, they are spiritual poems of unfailing inspiration, inevitable in phrase and wonderful in rhythm and expression. They are epic hymns of self-knowledge, and world-knowledge and God-knowledge. The imagery of the Upaniṣads is in large part developed from the type of imagery of the Veda. Ordinarily it prefers unveiled clarity of the directly illuminative image, but it frequently uses the same symbols in a way that is closely akin to the spirit of the older symbolism. The Upaniṣads are not a revolutionary departure from the Vedic mind but a continuation and development and to a certain extent an enlarging transformation. They bring out into an open expression what was held covered in the symbolic Vedic speech as a mystery and a secret. Ajātaśatru's

explanation of sleep and dream, passages of the *Praśna Upaniṣad* on the vital being and its motion are some of the examples of Upaniṣadic symbolism.¹²

Along with the Veda, Upaniṣads rank as *Śruti*, since they embody revelations and intuitions of spiritual experience. The Upaniṣads have been acknowledged to be the source of numerous profound philosophies and religions that flowed from them in India. They fertilised the mind and life of the people and kept India's soul alive through the centuries. Like a fountain of inexhaustible life-giving water, they have never failed to give fresh illumination. It is even being said that Buddhism was only a restatement of one side of the Upaniṣadic experience, although it represented a new standpoint and provided fresh terms of intellectual definition and reasoning. Even in the thought of Pythagoras and Plato, one could rediscover the ideas of the Upaniṣads. Sufism has been seen to be repeating the teaching of the Upaniṣads in another religious language. Even some of the modern thinkers of the East and the West seem to be absorbing the ideas of the Upaniṣads with living and intense receptiveness. And it may not be an exaggeration to say that there is hardly a main philosophical idea which cannot find an authority or a seed or indication in those ancient and antique writings. It has also been claimed that the larger generalisations of Science are found to apply to the truth of the physical Nature formulas which were discovered by the Upaniṣadic sages.

The Upaniṣads are Vedānta, a book of knowledge, but knowledge understood not as a mere thinking but as a seeing with the soul and total living in it with the power of inner being, a spiritual seizing by a kind of identification with the object of knowledge. Through this process of knowledge by identity or intuition the seers of Upaniṣads came easily to see that the self in us is one with the universal self of all things and that this self again is the same as God and Brahman, a transcendent Being or Existence, and they beheld, felt, lived in the inmost truth of all things in the universe and the inmost truth of man's inner and outer existence by the light of this one and unifying vision.

Hence, the three great declarations of the ancient Vedānta are: 'I am he',¹³ 'Thou art That, O Swetaketu',¹⁴ 'All this is the Brahman; this Self is the Brahman'.¹⁵

The main conceptions of the Upaniṣads remained in parts in the various philosophical systems and efforts were made from time to time to recombine them. *Nyāya*, *Vaiśeṣika*, *Sāṃkhya*, *Yoga*, *Pūrva Mīmāṃsā* and *Uttara Mīmāṃsā* bear the imprint of the Upaniṣadic thought, and the last one, particularly, has as its basic text, *Brahmasūtra*, which was composed by Bādarāyan, in which the quintessence of the Upaniṣads was expounded

aphoristically. *Brahmasūtra* came to be commented upon by various Ācāryas. This gave rise to at least five schools of Vedāntic interpretation, viz., Advaita of Śankarācārya, Viśiṣṭādvaita of Rāmānujācārya, Viśuddhādvaita of Vallabhācārya, Dvaitādvaita of Nimbārkaācārya, and Dvaita of Madhwācārya. *Bhagavad Gītā* is also considered to be an exposition of the essence of the Upaniṣadic teaching. The commentary literature on the *Upaniṣads*, *Brahmasūtra* and *Bhagavad Gītā* is continuing to develop even in our own times.

It is true that the Upaniṣads are mainly concerned with the inner vision and not directly with outward human action; yet, all the highest ethics of Buddhism and later Hinduism are emergences of the very life and significance of the truths to which they give expressive form and force, and they even present the supreme ideal of a spiritual action founded on the oneness with God and all living beings. It is for this reason that even when the life of the forms of the Vedic cult had passed away, the Upaniṣads still remained alive and creative and could generate the great devotional religions and inspire the persistent Indian idea of the Dharma.

By the time we come to the Upaniṣads, the original Vedic symbols had begun to lose their significance and to pass into an obscurity. The earlier stage of culture represented an old poise between two extremes. On one side, there was the crude or half-trained naturalness of the outer physical man; on the other side, there was an inner and secret psychic and spiritual life for the initiates. But this poise was disturbed because of the necessity of a large-lined advance. In its developing cycle of civilisation, India called for a more and more generalised intellectual, ethical and aesthetic evolution. This called for a new poise and new balance. At this juncture, the Upaniṣads saved the ancient spiritual knowledge by an immense effort, and the spiritual edifice created by the Upaniṣads guided, uplifted and penetrated into the wide and complex intellectual, aesthetic, ethical and social culture that came to be developed during the age that followed the age of the Vedas and the Upaniṣads.

IV

During this post-Vedic age, which extended right up to the decline of Buddhism, we see the rise of the great philosophies, many-sided epic literature, beginnings of arts and science, evolution of vigorous and complex societies, formation of large kingdoms and empires, manifold formative activities of all kinds and great systems of living and thinking. It was a birth time and youth of the seeking intellect, and a number of scientific or systematic

bodies of intellectual knowledge came up at any early stage. Actually, Vedāṅgas had begun to develop even before the Upaniṣads. *Māṇḍūkya Upaniṣad* mentions six Vedāṅgas: *Śikṣā* (Phonetics); *Kalpa* (Rituology); *Vyākaraṇa* (Grammar); *Nirūkta* (Etymology); *Chanda* (Metrics); and *Jyotiṣ* (Astronomy and Astrology). Each Vedāṅga takes up one aspect of the Veda and an attempt is made to explain it.

In due course, there developed a vast literature on these Vedāṅgas, expounding various systems of phonetics, rituals of sacrifices and rules of conduct of various kinds such as those described in *Srautasūtra*, *Gṛhyasūtras* and *Dharmasūtras*, principles and details of Vedic etymology, grammatical subtleties, various forms, meters and styles of poetry, and several systems of astronomical and astrological knowledge. There developed also considerable literature of *Pratiśākhya*, which dealt with the subtleties of grammar, meters and pronunciation pertaining to the *Śākhās*¹⁶ of the Vedas. Apart from the Vedāṅgas, there developed four sciences, known as Upavedas, viz., *Āyurveda*, *Dhanurveda*, *Gāndharvaveda* and *Arthaveda*. Here again, in due course, there developed a vast literature of expositions, commentaries and treatises.

Strong intellectuality of this period was inspired by the wide variety of spiritual experience and the synthetic turn so visible in the Vedas and the Upaniṣads. There was a conscious perception that spiritual experience is higher than religion and that what religion seeks can really be attained by the inner psychological discipline, which in due course came to be developed into a *Śāstra*, the *Śāstra* of Yoga. This allowed intellectuality to become free from the crippling effects of religious dogma, and we find that the intellectual development became multi-sided. Materialistic atheism, agnosticism, scepticism, too developed. Indeed, this intellectuality was austere and rich, robust and minute, powerful and delicate, massive in principle and curious in detail. The mere mass of the intellectual production during the period from Ashoka well into the Mohammadan epoch is something truly prodigious. This can be seen from the account which recent scholarship gives of it. And while evaluating this account it must be noted that what has been dealt with so far of this ancient treasure is a fraction of what is still lying extant and what is extant is only a small percentage of what was once written and known. And we also have to note that what was accomplished had for its aid the power of memory and the perishable palm-leaf. The colossal literature extended to various domains—philosophy and theology, religion and yoga, logic and rhetoric, grammar and linguistics, poetry and drama, medicine and astronomy and the sciences. It dealt also with politics and

society, music and dancing, architecture and painting, all the sixty-four accomplishments, and various crafts and skills. It may be said that even such subjects as the breeding and training of horses and elephants had their own *śāstras*. Each domain of thought and life had a systematic body of knowledge, its art, its apparatus of technical terms, its copious literature.

During this period, India stood in the first rank in mathematics, astronomy, chemistry, medicine, surgery and all the branches of physical knowledge which were practised in ancient times. In many directions, India had a priority of discovery. It is true that the harmony that was established between philosophical truth and truth of psychology and religion was not extended in the same degree to the truth of physical Nature. But from the beginning, starting from the thought of the Veda, the Indian mind had recognised that the same general laws and powers hold in the spiritual, the psychological and the physical existence. Omnipresence of life was discovered, and there was the affirmation of the evolution of the soul in Nature from the vegetable and the animal to the human form.

The philosophic mind started from the data of the spiritual experience, and it went back always in one form or another to the profound truth of the Veda and the Upaniṣads which kept their place as the highest authority in these matters. There was a constant admission that spiritual experience is a greater thing and its light a truer if more incalculable guide than the clarities of the reasoning intelligence. In the epic literature of the *Mahābhārata* and the *Rāmāyāṇa*, we find a strong and free intellectual and ethical thinking; there is an incessant criticism of life by the intelligence and ethical reason. We find in it multi-sided curiosity and desire to fix the norms of truth in all fields. But in the background there is a constant religious and spiritual sense and an implicit or explicit assent to the spiritual truth. In the field of art, there was insistence upon life and its creativity, but still its highest achievement was always in the field of the interpretation of the religio-philosophical mind. The whole tone of art during that period was coloured by a suggestion of the spiritual and the infinite.

The master ideas of the Vedas and the Upaniṣads governed the developing turn of imagination, its creative temperament and the kind of significant forms in which it persistently interpreted its perception of self and things and life and universe. The sense of the infinite and the cosmic generated by the Vedic hymns is seen in a great part of the literature of the subsequent ages even as we see it in architecture, painting and sculpture. And as in the Veda, even so here, there is a tendency to see and render spiritual experience in images taken from the inner psychic plane or in

physical images transmitted by the stress of a psychic significance and impression. The tendency to image the terrestrial life often magnified, as in the *Mahābhārata* and in the *Rāmāyaṇa*, reflects the Vedic influence.

In the field of collective life, Indian society developed its communal coordination of the mundane life of interest and desire, *kāma* and *artha*. But it governed its action always by a reference at every point to the moral and religious law, the *dharma*, and it never lost sight of spiritual liberation, *mokṣa*, as the highest motive and ultimate aim of the effort of life. At a still later stage, when there came about an immense development of the mundane intelligence and an emphatic stress of aesthetic, sensuous and hedonistic experience, there was a corresponding deepening of the intensities of psycho-religious experience. It may be said that every excess of emphasis on the splendour and richness and power and pleasures of life had its recoil and was balanced by a corresponding stress on spiritual asceticism. And throughout this development one can see the inner continuity with the Vedic and Vedāntic origins.

It is true that at one time it seemed that a discontinuity would take place. Buddhism seemed to reject all spiritual continuity with the Vedic religion. Buddhism also seemed to be a sharp new beginning. But the ideal of *nirvāṇa* came to be perceived as a negative and exclusive statement of the highest Vedantic spiritual experience. The eight-fold path also came to be perceived as an austere sublimation of the Vedic notion of the Right, Truth, and Law, which was followed as the way to immortality. The strongest note of Mahāyāna Buddhism which laid a stress on universal compassion and fellow-feeling was seen as an ethical application of the spiritual unity which is an essential idea of Vedānta. The Buddhistic theory of *karma* could have been supported from the utterances of the Brāhmaṇas and the Upaniṣads. Actually, the Vedic tradition absorbed all that it could be of Buddhism, but rejected its exclusive positions.

But there was a gradual fading out of the prominent Vedic forms and substitution of others. Symbol, ritual and ceremony were transformed; the lofty heights of the Vedic spiritual experience did not reappear as a predominant tendency, although there was a farther widening and fathoming of psychic and spiritual experience. The Vedic pantheon gradually faded out altogether under the weight of the increasing importance of the great Trinity, Brahmā—Viṣṇu—Śiva. A new pantheon appeared; its outward symbolic aspect expressed a deeper truth and larger range of experience, feeling and idea. The tradition of the Vedic sacrifice began to break down; the house of Fire was replaced by the temple. The devotional temple ritual came to replace to a great extent the *karmik* ritual of sacrifice. More precise concep-

tual forms of the two great deities, Viṣṇu and Śiva, came to replace the vague and shifting mental images of the Vedic gods. The *shaktis* of Viṣṇu and Śiva also came to dominate the religious scene. These new concepts became stabilized in physical images, and these images were made the basis for both internal adoration and external worship.

The esoteric teachings of the Vedic hymns which centred on the psychic and spiritual discipline disappeared, although some of its truths reappeared in various new forms. These forms as we see them in the Purāṇic and Tāntric religion and yoga were less luminous than the Vedic nucleus of spiritual experience, but they were wider, richer, complex and more suitable to the psycho-spiritual inner life.

The Purāṇo-Tāntric¹⁷ stage was marked by an effort to awaken the inner mind even in the common man, to lay hold on his inner vital and emotional nature, to support all by an awakening of the soul and to lead him through these things towards highest spiritual truth. This effort required new instruments, new atmosphere and new fields of religious and spiritual experience. While the Vedic godheads were to the most of their worshippers divine powers who presided over the workings of the outward life of the physical cosmos, the Purāṇic Trinity had even for the multitude a predominant psycho-religious and spiritual significance. But the central spiritual truth remained the same in both the Vedic and Purāṇo-Tāntric systems, the truth of the One in many aspects. As the Vedic godheads were forms of the Supreme, even so the Purāṇic Trinity was a triple form of the one supreme Godhead and Brahman; even the Shaktis were energies of the One Energy of the highest divine Being. But this truth was no longer reserved for the initiated few; it was now more and more brought powerfully, widely and intensely home to the general mind and feeling of the people.

The system of the hierarchy of the worlds that we find in the Veda was more intricate than the system found in the Purāṇas. In the Veda, the highest worlds constitute the triple divine principle; infinity is their scope, bliss is their foundation. These three worlds are supported by the vast region of the Truth whence a divine Light radiates out towards our mentality in the three heavenly luminous worlds of *swar*, the domain of Indra. Below is the triple system in which we live. This triple system consists of three earths, three heavens, *dyaus*, and the connecting mid-region (*antarikṣa*). In simpler terms, the triple lower world in which we live is the world of matter, life-force and pure mind. According to the Vedic idea, each principle can be modified by the subordinate manifestation of the others within it, and each world is divisible into several provinces. Into this framework the Vedic Ṛṣis placed all the complexities of the subtle vision and fertile imagery. The Purāṇic

system is a continuation of the Vedic system, but it is simpler. The Purāṇa recognises seven principles of existence and the seven Purāṇic worlds correspond to them with sufficient precision, thus:

<i>Principle</i>	<i>World</i>
1. Pure Existence— <i>Sat</i>	World of the highest truth of being (<i>Satyaloka</i>)
2. Pure Consciousness— <i>Cit</i>	World of infinite Will or conscious force (<i>Tapoloka</i>)
3. Pure Bliss— <i>Ānanda</i>	World of creative delight of existence (<i>Janaloka</i>)
4. Knowledge or Truth— <i>Vijñāna</i>	World of the vastness (<i>Maharloka</i>)
5. Mind	World of light (<i>Svar</i>)
6. Life (nervous being)	World of various becoming (<i>Bhuvār</i>)
7. Matter	The material world (<i>Bhur</i>)

The Vedic interpretation of life as a movement of sacrifice and a battle continued in the Purāṇo-Tāntric tradition also. According to the Veda, the struggle of life is a warring of Gods and Titans, Gods and Giants, Indra and Python, Aryan and the Dasyu. In the Purāṇas and Tantras also life is conceived as a struggle and battle between Devas and Asuras, Devas and Rākṣasas, between the armies of Gods and Goddesses and the armies of Āsuric, Rākṣasic and Paisācīk adversaries. The Vedic goal of achieving immortality recurs also in the Purāṇas and Tantras, where we have symbolic story of the search after the nectar.

The Vedic idea of the divinity in man was popularised to an extraordinary extent during the Purāṇo-Tāntric stage; there was a development of the concept of the *avatārs*, of the occasional manifestations of the divine in humanity; there was also the development of the idea of the Divine Presence, discoverable in the heart of every creature. New systems of yoga also developed, but the basis was the same, namely, secret of the power of concentration, of the method of concentration, and of the object of concentration. There was, however, a many-sided endeavour which opened the gates of Yoga on various levels and planes of consciousness. Many kinds of psycho-physical, inner vital, inner mental and psycho-spiritual methods came to be developed; but all of them had the common aim of the realisation of a greater consciousness and a more or less complete union with the One and Divine, or else an immergence of the individual soul in the Absolute. The

Purāṇo-Tāntric system provided a basis of generalised psycho-religious experience from which man could rise through knowledge, works or love or through any other fundamental power of his nature to some supreme experience and highest or absolute status.

V

After the Purāṇo-Tāntric stage, came the third stage of the development of religion and spirituality in India. The first stage consisted of the Vedic training of the physically minded man;¹⁸ the second stage took up man's outward life as also a deeper mental and psychical life, and brought man more directly into contact with the spirit and divinity within him. But now in the third stage, there was an attempt to take up man's whole mental, psychical and physical living so as to arrive at the first beginning of at least a generalised spiritual life. This is what we see in the emergence of great spiritual movement of the saints and Bhaktas after the decline of Buddhism and an increasing resort to various paths of yoga. During this stage, there was also a great problem of receiving Islam, and two great attempts were made to arrive at a new synthesis; one from the side of the Muslims, and the other from the side of the Hindus. The former was exemplified in the attempt of Akbar to create a new religion called Din-Illahi, and the latter was exemplified by the life and work of Guru Nanak. The work of Guru Nanak later gave rise to the astonishingly original and novel Sikh Khalsa movement. During this period, there was a tremendous churning of the spirit of India, and a great attempt was made to explore all aspects of human being and to develop them in such a way that they could all open up to the spiritual light and force. This attempt had not only an individual aspect but also a collective aspect. This was a remarkable attempt which could have revolutionised the collective life of India. But this was interrupted on account of several factors.

Among these factors was the fact of the exhaustion of the vital force as a result of a long march and effort from the earliest times of Indian history. This exhaustion was also due to the fact that since the sixth century BC there entered a current of culture which negated the meaning and the significance of cosmic life. This created confusion and disbalance resulting in excessive asceticism. This impoverished life and led to the neglect of social, economic and political conditions of the country. High ideals began to be exiled from active life, and rigidities of various kinds came to imprison the forms of life of individuals and collectivities. The exhaustion of vital

force also coincided with the political instability and the coming of the settlers from the West. Finally, the establishment of the British supremacy in India resulted in the extreme impoverishment of the Spirit of India.

VI

The third stage of religious and spiritual development of India could not bear its natural fruit, although it has done much to prepare a great possibility for the future. The message of the third stage is that the spiritualization of the collective life cannot be achieved if only the physical mind of man is trained or even if a greater effort is made to train the psychic-emotional part of man's nature. What is needed is to turn the entirety of mental, psychical and physical living of the individual and the collectivity to divinise the entire human life and nature. It is significant, therefore, that there arose from the middle of the nineteenth century a reassertion of the Indian spirit, and this reassertion is marked by three tendencies, namely, reaffirmation of the spiritual ideal, emphasis on dynamism and creative action, and insistence on collective domains and forms of life. At the beginning of this period there arose a galaxy of great personalities, like Raja Ram Mohun Roy and Dayananda Saraswati, Sri Rama Krishna and Swami Vivekananda, who filled India with a new breath and sowed the seeds not only of a spiritual awakening but also of social and political awakening. The new nationalist spirit was at once spiritual and social in character, and it symbolized a new vibration.

It is significant also that in this new awakening, the Veda was rediscovered, the Upaniṣads were rediscovered. The esoteric teaching of the Vedas which was confined only to initiates, during the Vedic period, seems in the new light to be a store from which we can even now draw illumination and power of regeneration. The new light does not advocate a mere revival or a prolongation of the Purāṇic system but points to something which the Vedic seers saw as the aim of human life and which the Vedāntic sages cast into the clear and immortal forms of the luminous revelation. And yet it is not to the Vedic forms that we are called upon to return. The great message of modern India, coming through its accomplished Ṛṣi, Sri Aurobindo, calls for the discovery of newer light and development of newer forms. Not to trace or retrace the old, but taking into account the treasures of the past and by liberating or developing new knowledge, even by hewing new paths we are called upon to find original solutions to build up a new centre of spiritual consciousness which can manifest that consciousness potently in all fields of activity, scientific, philosophical, cultural, social, economic, political.

VII

Significance of the Veda is not confined merely to the fact that it is the world's first yet extant Scripture, but that it is the earliest interpretation of Man and Divine and the Universe as also that it is a sublime and powerful poetic creation. The utterances of the greatest seers, Viśvāmitra, Vāmadeva, Dīrghatamas and many others touch the most extraordinary heights of māntric poetry. At the early stages of the Vedic tradition the substance of Indian religion and spirituality came to be determined by the varieties of deepest psychic and spiritual experiences shared and expressed by hundreds of the Vedic seers. It can be seen that the post-Vedic and later spirituality of Indian people was contained in the Veda in seed or in first expression.

A great force of intuition and inner experience, so evident in the Veda and the Upaniṣad, gave to the Indian mind the sense and reality of cosmic consciousness and cosmic vision. Perception of the One underlying reality, recognition of the perception of unity, as Vidyā, and the necessity of the individual to lift himself from Avidyā to Vidyā—these are the connecting threads of Indian religion and spirituality, and these we see repeatedly emphasised in the Vedic teaching. At the same time, we have to note that even while admitting the One without a second, *ekam eva advītiyam*, there was no paralysing exclusion in the Veda and the Upaniṣad, and there was a clear admission of the duality of the One and the distinction of the Spirit and Nature; and there was room also for various trinities and a million aspects of that One, *tad ekam*. This has created in the Indian mind aversion to intolerant and mental exclusions, and even when it concentrates sometimes on single limiting aspect of the Divinity—and seems to see nothing but that—it still keeps instinctively at the back of its consciousness the sense of the All and the idea of the One. Even when it distributes its worship among many objects, it looks at the same time through the object of worship and sees beyond the multitude of Godheads the Unity of the Supreme. What is of special significance is that this synthetic turn is not limited to the mystics or to philosophic thinkers, but it extends even to the popular mind, which has been permeated by the force of the thoughts, images, traditions and cultural symbols not only of the Veda and Vedānta but also by the Purāṇa and Tantra. There is in the Indian mind a pervasive synthetic monism, many-sided unitarianism, and large cosmic universalism.

This is not to deny the fact that there have emerged in the long course of Indian history tendencies, thoughts and even religious movements

characterised by exclusivism. There have been exclusive claims and counter-claims and even quarrels and intolerance. But the efforts at synthesis have tended to prevail. Even in the field of philosophy, while trenchant positions are not absent, synthetic turn eventually predominates. In the field of Yoga, too, there have been specialisations and exclusive claims and counter-claims; claims of the path of knowledge have opposed the claims of the path of action and devotion and vice-versa; but there have been powerful systems of the synthesis, such as those of the esoteric Veda, Upaniṣads, *Gītā* and Tantra. Even in later times, in the movements of saints and *bhaktas* there is a marked turn towards synthesis, and even in our own times, in the yogic life of Sri Aurobindo's integral yoga we have the latest effort and statement of the synthesis of yogic disciplines.

Catholicity of the Veda and the Upaniṣads has remarkable changes in the forms of Indian religion and spiritual culture, even while maintaining the persistence of their spirit. And if we examine the changes that have occurred we shall find in them a meaningful process of evolution and a certain kind of logic. Right from the Vedic times, there was a tendency in the Indian religion to provide means for the individual and collective life to develop by graded steps and reach and experience truths of higher and spiritual existence. It was recognised that at the beginning not many could safely and successfully reach the heights, but the pioneering leaders did not accept the theory that many must necessarily remain for ever on the lower ranges of life and only a few climb into the free air and the light, but were moved by the spirit to regenerate the totality of physical life on the earth. It is true that this spirit was not at all times and in all its parts consciously aware of its own total significance. But the total drift of the manifold sides and rich variations of the forms, teachings and disciplines of Indian religion and spirituality indicate that the aim pursued was not only to raise to inaccessible heights the few elect, but to draw all men and all life and the whole human being upward, to spiritualize life and in the end to divinise human nature.

Indian spirituality, as seen in the Veda recognised both the spiritual and physical poles of existence, and sought the experiences and realisation of higher planes of the Spirit even in physical consciousness (*prithvi*). The legend of the Angiras *Ṛṣis* indicates the effort to discover the lost sun and herds of light in the caves of darkness, symbolising physical inconscience. It may even be said that the Yoga of the Veda seems to suggest that the discovery of the light in Surya Savitri is followed and completed by the discovery and uncovering of the light in the very depths of darkness of the

Inconscient, *tamas*. Not the rejection of Matter and material life but realisation that Matter too is Spirit and that material life too can bear and manifest the spiritual light and bliss—this seems to be the inner basis of the Vedic teaching.

It is this unitive perception that could explain the drift of Indian religion and spirituality towards a wide and many-sided culture: It is true that on its more solitary summits, at least in its later periods, Indian spirituality tended to a spiritual exclusiveness, which was, whatever its loftiness, quite impressive and excessive. Actually this exclusiveness imposed on Indian culture a certain impotence to deal effectively with the problems of human existence; consequently, there came about a general decline in science, in philosophy, and in all other domains of life. On the other hand, the previous training provided under the Vedic religion to the physically-minded early common man and under the post-Vedic and Purāṇo-Tāntric religion to later period common man with fairly well developed faculties had created favourable conditions for the growth and development of multi-sided religious and spiritual movement. The movement attempted to synthesize conflicting tendencies and to invite larger and larger sections of the society to the possibilities of the multi-sided spiritual training and development. Even though there was a general arrest of these new developments, the Indian Renaissance has now provided fresh conditions, and the most conscious and potent expression of the new spirituality has declared the aim not of individual salvation but of collective salvation. It has rejected the exclusive solution of the problems of human life in the attainment of world-negating spirit; it has rather affirmed the possibility of the highest spiritualizing of life on the earth.

The earliest preoccupation of India, as expressed in the Veda, was the exploration of the Spirit in Matter and of Matter in Spirit; the intermediate preoccupation was with the seeking and experiment in a thousand ways of the soul's outermost and innermost experience marked by various conflicts and even exclusive affirmations and denials under an overarching tendency towards multi-sided development of the spiritual, ethical, intellectual, aesthetic, vital and physical parts of the being and some kind of synthesis. The latest trend takes up the burden and treasure of the gains of the past and looks towards the future with some kind of basis of effective realisation where tasks of the establishment of the divine life on the earth for full participation by the entire human race could be undertaken.

While outlining these tasks, particularly, of the nascent India, Sri Aurobindo states:

The recovery of the old spiritual knowledge and experience in all its splendour, depth and fullness is its first, most essential work; the flowing of this spirituality into new forms of philosophy, literature, art, science and critical knowledge is the second; an original dealing with modern problems in the light of Indian spirit and the endeavour to formulate a greater synthesis of a spiritualized society is the third and most difficult. Its success on these three lines will be the measure of its help to the future of humanity.¹⁹

NOTES AND REFERENCES

1. See, for example, RV I.1.2.
2. According to Shri A.C. Das, Vedas could have been composed any time between 250th and 750th century BC. According to Lokamānya Tilak, the estimated period would be any time between 45th and 50th century BC. This coincides with the view of Professor Haug, Professor Ludwig and Professor Jacobi. Professor Whitney places the period any time between 15th and 20th century BC. Professor Max Muller believes that the Veda was composed during the 13th century BC.
3. RV I.164.46.
4. See also RV I.164.39; RV I.164.46; RV X.71.
5. RV IV.1.17.
6. RV I.71.3.
7. RV I.72.9.
8. See also RV I.68.1-3.
9. Triple Infinite of the Veda, which was formulated as Sachchidānanda in the Upaniṣad.
10. Brāhmaṇas contain detailed analysis of various categories of sacrifices, their rituals and procedures. They include also collections of history, legends, anecdotes and narrations of stories connected with individuals. The important Brāhmaṇas are: *Aitareya Brāhmaṇa*, *Śatapatha Brāhmaṇa*, *Taittiriya Brāhmaṇa*, *Kathaka Brāhmaṇa*, *Jaiminiya Brāhmaṇa* and *Gopatha Brāhmaṇa*. A large number of Brāhmaṇas have been lost.
11. In the *Muktapaniṣad* it is mentioned that the total number of Upaniṣads is 108, and they are derived from the four Vedas. The Upaniṣads laid down the process of realisation of the Brahman, the ultimate Reality, which begins with the *Brahmajijnāsā*, aspiration to know the Brahman and it continues through the hearing of the Upaniṣads, reflection on the Upaniṣads and dwelling on the Upaniṣads. Important Upaniṣads are: *Aitareya*, *Māṇḍūkya* and *Kauṣītaki*, which are related to Ṛgveda; *Taittiriya*, *Katha* and *Śvetāśvatara* which are related to *Krishna Yajurveda*; *Bṛhadāraṇyaka* and *Īsha*, which are related to *Shukla Yajurveda*; *Kena* and *Chhāndogya*, which are related to *Sāmaveda*; and *Praśna* and *Muṇḍaka*, which are related to *Atharvaveda*.
12. We may also refer to the passage of the Taittiriya in which Indra appears as a power of the divine mind. The passage of the *Praśna Upaniṣad* may also be referred to where the power and the significance of the mystic syllable AUM are described.

As an example of greater clarity of statements, which are nearer to our intellectual apprehension, we may refer to the passages of the *Katha Upaniṣad*, where the knowledge of the Puruṣa, no bigger than a thumb, as man's central self is given.

13. *Chhândogya Upaniṣad*: 4.11.1.
14. *Ibid.*, 6.8.7.
15. *Ibid.*, 3.14.1; also *Bṛhadāraṇyaka Upaniṣad*: 2.5.19.
16. The tradition of transmission of the recitation of the Samhitās gave rise to various recensions or Śākhās. The total number of Śākhās in the ancient period was 1131; but at present only 10 Śākhās are alive.
17. According to the tradition, the word Purāṇa is so-called because it is supposed to refer to the most ancient knowledge. It is said that Brahmā had received the knowledge containing the Purāṇas from the Supreme Divine; Brahmā transmitted it to his four mind-born sons, one of whom Sanat Kumara transmitted it to Nārada, who, in turn, transmitted it to Krishna Dwaipayana, Vedavyāsa. Veda Vyāsa composed that knowledge in 18 books, each one of them is called Purāṇa. There are also a number of Upapurāṇas. Purāṇas describe the creation of the universe, development of the universe, and the dissolution of the universe. Apart from many legends, Purāṇas contain ideas relating to birth, death and the condition of the soul after the death of body. They also deal with the question relating to philosophic and yogic matters. Most importantly, Purāṇas are related to great deities, particularly of Brahmā, Viṣṇu and Śiva. An important contribution of the Purāṇa is related to the concept of divine incarnation, *avatāra*.

The texts connected with Tantra are numerous, probably sixty-four or even more. The tāntrik treatise is generally in the form of a dialogue between Shiva and his consort and it teaches mystical formulae for the worship of the deities or the attainment of super-human powers. The tāntric yoga is a kind of synthesis of yogic practices contained not only in Karma Yoga, Jñāna Yoga, and Bhakti Yoga but also in *mantra yoga*, *hatha yoga* and *rāja-yoga*. The tāntrik synthesis attempts to emphasise the notion of the divine perfectibility of man, which was also in the Vedic teaching, but which was overshadowed in the intermediate ages.
18. We are not considering here the esoteric teaching of the Veda, which was limited only to the initiates, and which addresses itself to intellectual, vital and physical aspects of training also.
19. *The Foundations of Indian Culture*, Vol. 14 of the Centenary Collection, p. 409.

Four Questions That History Might Answer

J. V. NARLIKAR

INTRODUCTION

History is more than a catalogue of events and characters that occupied the stage of the world in the past. It is a chronological sequence of the evolution of human societies and cultures. Although specific human beings and specific events do play critical roles in turning the evolutionary path in a different direction there are also slow but steady changes going on as knowledge accumulates and societies adapt themselves to its growing store. Science and technology, howsoever primitive in the past are part of that knowledge and have played influential roles in shaping civilizations. The discovery of fire and the trick of producing it artificially, the transition from stone to metal in making implements and the discovery of agriculture have been cornerstones in such historical development of mankind.

We often talk of the history of science as if it were an isolated branch of history that deals with how scientific knowledge evolved, who contributed to its major discoveries, how its controversies arose and were laid to rest, how circumstances prevented its progress and how accidents led to new breakthroughs. In my opinion history of science should go further than all this, extending its scope to the interaction of science with society. For, science has been one of the influences in shaping the society and social influences have controlled scientific thinking.

It is in this context that we need to look at our own history and use whatever investigatory tools we have towards answering questions relating to the state and evolution of scientific thought as well as questions relating

to the antiquity of some of our ancient works from scientific allusions in them. This article raises a few questions of this kind.

While raising these questions let me confess to being a total novice in the field of history of science. It is thus quite possible that my questions are not well posed in the jargon of experts; perhaps some of them have already received answers: in any case it is quite likely that they may have been discussed by the cognoscenti. My sole reason for raising them here is a layman's curiosity.

Q.1: What is the scientific content of the Vedas?

We often hear very sweeping statements that all important discoveries of modern science are to be found in the Vedas, if only we learn how to interpret them. Also, much is made of the so-called Vedic mathematics. And, as corollaries of such statements, we are told that because there are descriptions of sophisticated guided missiles in the *Rāmāyaṇa* and the *Mahābhārata* the societies described in those epics were technologically advanced.

For the typical Indian mind anxiously seeking parity with the West it is tempting to look for a glorious past as a compensation for the present 'developing nation' status. Scholars of history have to set aside such prejudices and objectively assess whatever information that can be gleaned from the ancient literature.

Let us look at the Vedic Mathematics in that light. So far as I have seen its expositions they look like a compendium of methods of quick calculations. None of them to my knowledge contain essentials of higher mathematics, like results from number theory, results from higher algebra or theorems of geometry let alone the more advanced levels of topology, analysis or algebraic geometry. I will be only too happy to be proved wrong by scholars of Vedic Mathematics, but this will require demonstration of a sophisticated mathematical result starting from a well defined set of axioms.

Let us next consider the claim for high technology in the ancient times. To base such claims on epics which are literary works rather than technical accounts is like concluding from the reading of Grimms' Fairy Tales that the Europeans of the seventeenth to nineteenth centuries were versatile in sorcery and magic. Let us instead ask the following relevant questions. Is there anywhere a description of what we consider today the basic amenities like water on tap, drainage system, electric lighting etc.? Simpler than the nuclear power or ballistic missile technology is the technology that produces electric power and delivers it to urban populations. Is there any evidence that the forces of electricity and magnetism were known and harnessed for power?

It is claimed that some Vedic psalms contain a description of how the Sun derives its power from nuclear fusion of hydrogen to helium. Frankly, even if the description is taken to be as claimed it does not tell us about the internal constitution of the Sun, what keeps it in equilibrium, how is the energy transported from the central core to the surface, etc., which in modern framework requires the knowledge of the forces of gravity, electricity and magnetism and of hydrostatics and radiative transfer. To say simply that the Dirghatama Rishi knew about nuclear fusion as the source of solar energy without filling in the above aspects of solar interior is giving a less than complete picture.

To put it in a nutshell, what we require is the equivalent of a technical text rather than a superficial poetic description. It is argued that the Vedas do contain that information also, only it needs to be dug out by 'decoding' the language of the psalms. If so we need a unique and unambiguous key to that code. That is, the code should be agreed upon by at least a few scholars in the field *before* the interpretation is undertaken. Only then the attempt will command credibility. It is certainly worth taking up such an exercise provided one is not preconditioned to arrive at an already known answer from Western science. Moreover, the case will be strengthened if such an attempt reveals some scientific truth hitherto unknown to modern science.

Q.2: Can astronomical allusions be used to date ancient writings?

Lokmanya Bal Gangadhar Tilak in his monograph *The Orion* had undertaken a unique exercise which is briefly described below.

Although Tilak is well known as a freedom fighter he was also a Sanskrit scholar with interest in mathematics and astronomy. It was while writing his famous commentary on *Gītā* (known as the *Gītārahasya*) that a verse in that volume set him thinking.

In Chapter 10 of the *Gītā*, Lord Krishna identifies himself with excellence in all things in nature, living or non-living. The line which attracted Tilak's attention was

Māsānām mārḡaśīrṣoḥam ṛtunām kusumākaraḥ,

meaning that amongst the months he is *mārḡaśīrṣhā* while in seasons he is 'spring'.

According to the present Hindu calendar, the month of *mārḡaśīrṣhā* (identified with the constellation 'mrīgashiras' or the Orion) does not come in spring but in autumn. Why this apparent discrepancy? Why does not the 'best' month belong to the 'best' season?

Tilak's argument which is given in detail in his monograph *The Orion* rests on the premise that the above reference was correct at the epoch it was made. Because of the precession of equinoxes the 'first' month of the year (which was identified with the spring equinox) happened to be *mārgashirshā* then; but it is not so now. Going further in his researches Tilak looked for references to seasons and constellations in the Vedas and argued that to reconcile the apparent discrepancies therein one has to assume a substantial precession of the equinoxes. And from these astronomical inputs one can estimate the epoch when the references in the Vedas were written. Tilak's calculations set the antiquity of the Vedas and the initial Aryan period as far back as 6000 BC.

Other scholars dispute this estimate which, they claim, makes the Vedas far more ancient than estimated by other methods based on evolution of literature, history and anthropology. On astronomical grounds, however, Tilak's approach is hard to fault. Its weakness lies in how clear-cut are the astronomical references on which the theory rests. As I mentioned earlier Vedic language is neither easy nor unambiguous. Perhaps a more systematic search along Tilak's lines is needed to improve the estimates given in *The Orion*.

The above exercise illustrates a possible combination of history, literature and astronomy. Other astronomical allusions include eclipses, rising and settings of certain *nakṣatras* in relation to planets, comets and so on. The planetary motion despite some secular and irregular effects does provide a good clock whose accuracy is being continually improved by better and better computer programmes. Some well-known comets like Halley's comet can also be used as period indicators. If literary quotes about astronomical sightings can be authenticated as genuinely belonging to the times of the work concerned (and not added subsequently!) then the astronomical clock can be used effectively as a check on the period concerned.

Q.3: Were any supernovae observed in India during the Siddhāntic period?

I begin with the example of the Crab Nebula which is so well known to astronomers as the sighting of an exploding star by ancient cultures. I mention this example because it belongs to the time when Indian astronomy was flourishing in its Siddhāntic period. (I take the Siddhāntic period as from Āryabhaṭa in the fifth century to Bhāskara II in the twelfth century.)

The astronomers in China and Japan nine centuries ago were accustomed to keeping meticulous records of all heavenly bodies. Their purpose in doing so was largely astrological. For it was widely believed that if the

ruler of the country strayed from the straight and narrow path of virtue and behaved badly, he would be warned of punishment by God; and the warning would appear through unusual happenings in the sky. So it was the duty of the court astronomer to keep a close watch on the heavens and to report anything uncommon.

Against the well-regulated movements of stars and not so well regulated but still predictable movements of planets, the unusual occurrences usually consisted of eclipses of the Sun or the Moon, meteor showers or visits from comets. The astronomers during the Sung Dynasty were certainly not prepared for what they saw on 4 July, AD 1054 (date as per today's calendar!). Their records reads^a:

On a Chi-Chhou day in the fifth year of Chi-Ho reign period a 'guest star' appeared at the south-east of Thien-Kaun measuring several inches. After more than a year it faded away.

The appearance of a new star would certainly cause comment, especially when it was bright enough to be visible by day being about five times as bright as Venus in the morning or evening! The star, however, did not stay bright for long and began to fade. In two years, it was not visible to the naked eye. Its location in the sky relative to the background of other stars was fixed, however. The Chinese and Japanese records of the position 'several inches south-west of Thien Kaun' imply Zeta Tauri in the constellation of the Bull. Because the star made only a transient appearance in the heavens, it was called a 'guest star'.

Where else in the world did people see this remarkable event? It should have been seen in India, Europe and Middle East and also in the American continents. Unfortunately, we do not have meticulous records available.

As I mentioned, the date of the Crab supernova falls within the golden age of Indian astronomy and so it is pertinent to ask if the Indian astronomers had recorded this unique event. Even though 4 July falls within the south-west monsoon period when the skies are overcast, it is hard to imagine that the entire subcontinent was under a cloud cover. Moreover, even after the actual explosion the object was visible as an exceptionally bright star for several days. It would have been hard to miss.

It is argued that Indians never recorded anything and ours was an oral tradition. This may be so: but still I feel that during the Siddhāntic period when astronomers did write books, there must have been records. It is also likely, as in the Chinese case the records may have astrological significance and may have been discussed in that context. Also, aside from the Crab

^a *History of the Sung Dynasty*, by Ho Peng Yoke (1962).

Nebula, one may ask if there were any references to even earlier supernovae, since one would expect to see some such spectacular event once in two to three centuries.

Q.4: Why did scientific activity decline after the Siddhāntic Period?

With a few exceptions, after the twelfth century, the leadership that India enjoyed in astronomy and mathematics petered out. Indeed, by the time a few centuries later, as Europe woke up to the new age of science and technology there was hardly any activity in these fields in our country. *Why did this happen?*

This question has been pondered over by many on various occasions. The reasons given also are diverse. I summarize them below:

1. In Europe the climate was unfriendly and survival under wintry conditions was always a challenge. Challenge brings forth the best in a population. Thus many left to look for more lucrative colonies and their adventures on the high seas required them to devise science based navigational aids as well as technology of shipbuilding. Those who remained also discovered that science and technology provide means of improving living conditions and so actively sought discoveries and inventions.

The climate in India by contrast is benign and does not pose challenges for existence of the same order as in Europe. Further there were religious taboos on leaving our shores which actively discouraged colonial adventures.

2. Our religious and social values have always stressed simple living and denial of worldly goods. This attitude, while admirable in many ways, discourages attempts to seek comfort and luxury. Thus the lure of applied science and technology was never so strong in the Indian ethos.
3. Science advances through a spirit of enquiry and not through rote learning. The Indian system of education was largely through oral recitation of the *śāstras* in which thoughts and precepts orally passed on through centuries only were propagated to the detriment of anything new. It required strong original thinkers like Āryabhaṭa and Bhāskara to add new ideas to such a system. Unfortunately such strong personalities were not forthcoming.
4. In Europe, science and technology received patronage from the rich aristocracy as well as from the royalty. The Royal Society and the French Academy are examples of royal patronage. But the main point is that even rich private individuals felt it worthwhile to support scientific pursuits just as they supported music and the fine arts. In India support for

the latter existed but not for the former. A Mughal emperor would patronize a Tansen or build a Taj Mahal but he did not think it necessary to support science.

For this neglect we had to pay a heavy price. For the British could control India not simply because of their policy of 'divide and rule' but also because of the tremendous edge they enjoyed over the natives in access to science and technology.

These are possible answers; but do they tell the whole story? I pose this question to the experts. The answer may hold guidance for the present also. For today science and technology have taken control of our lives and history may help guide us in our appreciation of these subjects.

CONCLUDING REMARKS

I think I have aired my ignorance sufficiently to convey a few areas in which research in the history of science may offer useful information. The word 'ignorance' stresses the possibility that I may not be aware that the information I have sought here already exists. In any case the project of putting together the whole story of evolution of scientific thought in the sub-continent over several millennia promises to be very rewarding and the questions I have posed are but the tip of the iceberg that research in this field will bring out.

Mathematical and Astronomical Heritage of India

A. K. BAG

INTRODUCTION

The Indians in ancient time recognised two types of knowledge: *Aparāvidyā* (Inferior knowledge) and *Parāvidyā* (Superior or Spiritual knowledge). An act of worship done with a specific worldly desire was considered an inferior form of worship and was popular with the kings. *Aparāvidyā* enables man to attain material progress, enrichment and fulfilment of life and *Parāvidyā* ensures attainment of self-realization or salvation in life (*Chānd. Up.* 7.17; *Munḍa. Up.* 1.2.4–5). The vedic people, in general, made interesting synthesis by adopting *nitya* (perpetual or daily) and *kāmya* (optional for wish-fulfilment) sacrifices or offerings. The first was supposed to bring happiness to the family and second was to give material progress. The perpetual sacred fires and the optional fires were placed on altar of various shapes. About the reasons which might have induced the ancient Indians to devise all these strange shapes, the *Rgveda* (1.15.12) says, 'He who desires heaven, may construct a falcon shaped altar, for falcon is the best flyer among the birds'. These may appear to be superstitious fancies but have led to important contributions in geometry and mathematics because of their conviction in social value systems.

The search for right time for religious, agricultural, New Year and other social festivals gave the motivation for recording the recurrence of repeated events from seasons, stars, movement of planets, moon, etc. This helped to develop many a framework for mapping movements of heavenly bodies with reference to East, West, North and South points, *nakṣatras*, calendar,

yuga, *mahāyuga* and movements of planets for mean and true positions of planets. Various mathematical and trigonometrical tables were also formulated for better and better results. The *Vedāṅga Jyotiṣa*¹ mentions as under:

'Having saluted Time with bent head, as also Goddess Saraswati, I shall explain the lore of Time, as enunciated by sage Lagadha.' He further placed astronomy in the central stage and said, 'As the crests on the head of the peacocks, the jewels on the serpents, so is the (*jyotiṣa gaṇitam*) held at the head of all lores among all *vedāṅga śāstras*'. *Gaṇita* is a variant reading for *Jyotiṣa* meaning computation which is the essence of this science.

Another tradition which has enriched specialized activities in mathematics and astronomy is the *guru-śiṣya-paramparā* (teacher-student tradition). Different *recensions* of vedic schools, *Śulbakāras*, *Jyotiṣkāras* (Varāhamihira gives names of 20 scholars before him), Kusumpura school, schools of Ujjain and Asmakadeśa, and Jain and Buddhist schools also are well known in this connection.

Besides these, there were commercial and other problems which were tackled for *Lokavyāvahārārtha*, used for common people. The restriction and emphasis were also assured on social use and value systems which helped people to take up different activities for commerce, education and other areas. These helped undoubtedly to concretize knowledge resulting to original contributions to mathematics and astronomy.

Construction of Altars, and Nature of Knowledge

The ritual connection of Indian geometry, as elaborated by Thibaut and Burk, has been intensively discussed by Datta, Seidenberg, Sen and Bag, and others.² The ceremonies were performed on the top of altars built either in the sacrificer's house or on a nearby plot of ground. The altar is a specified raised area, generally made of bricks to keep the fire. The fire altars were of two types. The perpetual fires (*nitya agnis*) were constructed on a smaller area of 1 sq. *puruṣa* and optional fires (*kāmya agnis*) were constructed on a bigger area of $7\frac{1}{2}$ sq. *puruṣas* or more, each having minimum of five layers of bricks. The perpetual fires had 21 bricks and optional fires had 200 bricks in each layer in the first construction and the number of bricks became more in the subsequent construction with other restrictions. For optional fire altars, the whole family of the organiser had to reside by the construction site of the optional fire altar, for which another class of structure known as *mahāvedī* and other related *vedīs* were made. However, a summary of these types of altars with ground shapes are grouped below:

- (a) *Perpetual Fire Altars* (Area coverage: 1 sq. *puruṣa*): *Āhavanīya* (square), *Gārhapatya* (circle/square), *Dakṣiṇāgni* (semi-circle).
- (b) *Optional Fire Altars* (Area coverage: $7\frac{1}{2}$ sq. *puruṣa*): *Caturasraśyenacit* (hawk bird with sq. body, sq. wings, sq. tail), *Kaṇkacit* and *Alajacit* (bird with curbed wings and tail), *Prauga* (triangle), *Ubhayata Prauga* (rhombus), *Ratha-Cakracit* (circle), *Dronacit* (trough), *Śmaśānacit* (isosceles trapezium), *Kūrmacit* (tortoise), etc.
- (c) *Vedis: Mahāvedī* or *Saumikī vedī* (isosceles trapezium) *Sautrāmaṇi vedī* (isosceles trapezium, and also one third of the *mahāvedī*), *Paṭīrkī* (isosceles trapezium or a square, area one third of *Sautrāmaṇi vedī*), *Prāgvaṃśa* (rectangle).

One can guess the nature of knowledge which could originate from such altar constructions. However, the *śulbasūtras* of Baudhāyana, Āpastamba and other schools have summarised these knowledge as available from the *Samhitās* and *Brāhmaṇas*. Both Baudhāyana and Āpastamba belonged to different schools but follow a similar pattern which also suggest that these schools inherited the knowledge from older schools. While giving details, the *Śulbasūtras* use the word *viññāyate* (known as per traditions), *vederviññāyate* (known as per vedic tradition), etc. very often. A summary of these knowledge will be of great interest.

Baudhāyana gives various units of linear measurements viz., 1. *prādeśa* = 12 *aṅgulas*, 1 *pada* = 15 *aṅg*, 1 *iṣā* = 188 *aṅg*, 1 *akṣa* = 104 *aṅg*, 1 *yuga* = 86 *aṅg*, 1 *jānu* = 32 *aṅg*, 1 *śamyā* = 36 *aṅg*, 1 *prakrama* = 2 *padas*, 1 *aratni* = 2 *prādeśas*, 1 *puruṣa* = 5 *aratnis*, 1 *vyāyāma* = 4 *aratnis*, 1 *aṅg* = 34 *tilas* = $\frac{3}{4}$ inch (approx.). Knowledge of rational numbers like 1, 2, 3... 10, 11... 100... 1000, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{3}{2}$, $\frac{5}{12}$, $7\frac{1}{2}$, $8\frac{1}{2}$, $9\frac{1}{2}$, etc. were used in decimal word notations and their fundamental operations like addition, subtraction, multiplication and division were carried without any mistake.

Baudhāyana had knowledge of square, rectangle, triangle, circle, isosceles trapezium and various other diagrams and transformation of one figure into another and vice-versa. Methods of construction of square by adding two squares or subtracting two squares were known. The area of these figures were also calculated correctly. That the length, breadth and diagonal of a right triangle maintains a unique relationship, $a^2 + b^2 = c^2$, where a = length, b = breadth and c = hypotenuse or in other words (1, 1, $\sqrt{2}$) ($\sqrt{2}$, 1, $\sqrt{3}$) formed important triplets thereby forming an important basis for number line, and were used for construction of bricks and geometrical figures. For easy verification, *Śulbakāras* suggested triplets ex-

pressed in rational and irrational numbers like (3, 4, 5), (12, 5, 13), (15, 8, 17), (7, 24, 25), (12, 35, 37), (15, 36, 39), (1, 3, $\sqrt{10}$), (2, 6, $\sqrt{40}$), (1, $\sqrt{10}$, $\sqrt{11}$), (188, $78\frac{1}{3}$, $203\frac{2}{3}$), (6, $2\frac{1}{2}$, $66\frac{1}{2}$), (10, $4\frac{1}{6}$, $10\frac{5}{6}$) and so on. A general statement on 'Theorem of Square on the Diagonal' was also enunciated thus: 'The areas (of the squares) produced separately by the length and the breadth of a rectangle together equals the area (of the square) produced by the same diagonal'. This has been wrongly referred to Pythagoras who was associated with the triplet (3, 4, 5) and theorem is known as Pythagorean theorem. The Indian knowledge is based on rational and irrational arithmetical facts and geometrical knowledge of transformation of area from one type to the other and its importance was perhaps correctly understood. How the Babylonians, Egyptians, Chinese and the Greeks came upon the knowledge of triplets but not the general statement is equally important for an interesting study.³

The *Śulbasūtra* tradition vanished. Only a limited commentary from a later period is available. Whether the tradition has been lost or the elements have been absorbed in temple architecture is still to be investigated and may form the part of other studies.

Decimal Scale, Decimal Place-value, Numerical Symbols and Zero

'Our numerals and the use of zero', observes Sarton⁴ (1955), 'were invented by the Hindus and transmitted to us by the Arabs (hence the name Arabic numerals which we often give them)'. The study of Sachs, Neugebauer on Babylonian tablets, Kaye and Carra de Vaux on Greek sciences, Needham on Chinese Sciences and study of Mayan Culture have many interesting issues. The study of scholars like Smith & Karpinski, Datta, Bag and Mukherjee⁵ have analysed Indian contributions, but still there is need for a comprehensive volume. However, the salient points may be of interest: The Indians had three tier system of word-numerals starting from the *Samhitās* as follows:

- (a) *eka* (1), *dvi* (2), *tr* (3), *catur* (4), *pañca* (5), *ṣaṭ* (6), *sapta* (7), *aṣṭa* (8) and *nava* (9).
- (b) *daśa* (10), *viṃśati* (2×10), *triṃśat* (3×10), *catvāriṃśat* (4×10), *pañcāśat* (5×10), *ṣaṣṭhi* (6×10), *saptati* (7×10), *aṣīti* (8×10) and *navati* (9×10).
- (c) *eka* (1), *daśa* (10), *śata* (10^2), *sahasra* (10^3), *ayuta* (10^4), *niyuta* (10^5), *prayuta* (10^6), *arbuda* (10^7); *nyarbuda* (10^8), *samudra* (10^9), *madhya* (10^{10}), *anta* (10^{11}), and *parārdha* (10^{12}).

The names and their order have been agreed upon by almost all the

authorities for (a) and (b), whereas there is variation in (c) where mostly one or two new terms have been added later. The numbers below 100 were expressed with the help of (a) and (b) sometimes following additive or subtractive principles, e.g. *trayodaśa* ($3 + 10 = 13$), *unaviṃśati* ($20 - 1 = 19$), while for numbers above hundred, groups (a), (b) (c) were used. For example, *sapta śatāni viṃśati* = (720), *ṣaṣṭhiṃ sahasrā navatiṃ nava* = (60,099).

One feature of the application of the scale is that it has been used in higher to lower order (*sahasra*, *śata*, *daśa* and lastly the *eka*). The real problem started when the numerical symbols began to appear. The *aṣṭa-karṇī* or *aṣṭamṛdam* fairly indicate that vedic people identified eight marks but whether they identified other symbols is not known. The *Mahābhārata* (III. 132–34) narrates a story in which it says that 'The signs of calculation are always only nine in number'. The *Aṣṭādhyāyī* of Pāṇini (450 BC) used the word *lopa*, and Patañjali the word *śūnya* in connection to metrical calculations. When Brāhmī and Kharoṣṭhi numerals/alphabets appeared on the scene, there was a lot of confusions creating more problems for ordinary business people and the mathematicians and astronomers as to how to use the numerical symbols and adjust with the existing decimal system. The early inscriptions show the number system was additive and did not use decimal scale. Moreover numerical symbols were many in the beginning and was difficult to decipher the correct meaning.

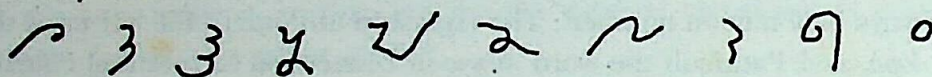
The first attempt of a synthesis of the vedic decimal system with the prevalent situation was possibly made by the Jains. The *Anuyogadvārasūtra* (100 BC) has described the numerals as *aṅka* and describes decimal scale as decimal places (*gaṇanāsthāna*) and their numeral vocabulary was analogous to that of the Brāhmanic literature. They have enlarged these places to 29 places and beyond, and we find more clear statement in mathematics cum astronomical texts from Āryabhaṭa onwards in expressions like *sthānānam daśaguṇam syāt* (from one place to next it should be ten times) and *daśaguṇottarāḥ saṃjñāḥ* (the next one is ten times the previous one). This indicates that the scale was merged with the *places*, and the system became very simple. For example, the Vedic numbers: *sapta śatāni viṃśati* and *ṣaṣṭhiṃ sahasrā navatiṃ nava* reduces to:

<i>sahasra</i> (10^3),	<i>śata</i> (10^2),	<i>daśa</i> (10),	<i>eka</i> (1)	Places
	7	2	0	= 720
60	0	9	9	= 60,099

The vedic scale was from higher to lower order (*sahasra*, *śata*, *daśa* and *eka*). But later, the order of the scale was changed from left to right (*eka*, *daśa*, *śata*, etc.). This is obvious when we think that in vedic system all words

were spoken, and in the latter system the scale obviously followed the written style (that is left to right) and the place values were from *eka* to higher order. Moreover the symbols were not standardised and interpreted differently in different regions. To avoid this problem experts coined synonymous words and used them as symbols in decimal place-value in lower to higher order and the actual number was obtained by reversing the number. For example: *śunya* (0)—*dvi* (2)—*pañca* (5)—*yama* (2) was actually 2520.

The real break-through is found in the *Bakhshālī Ms* (BM)⁶ (c. AD 400), a compendium in commercial mathematics found in Kashmir written in *Sāradā* script which used ten symbols for numerals one to nine and zero in decimal place-value system. B.B. Datta says that it is a commentary or a summary of an earlier text. The symbols are:



A few examples are given below:

330

(BM, 17 verso) = 330

34223

(BM, 56 recto) = 846720

The Kashmirian *Atharvaveda* also used the similar symbols.

Association of a decimal scale with place-value was so popular in Indian tradition that it was not even referred. The popularity went so deep that even Śaṅkarācārya (c. AD 800), the great social reformer, pointed out that the same unit sign if placed in unit, tenth and hundredth places becomes 1, 10, 100. The men in business or in elementary schools (*pāṭhśālā*) used wooden board (*pāṭh*), hence the name *pāṭhgaṇita*, for quick calculation, in which dust was spread and finger or hard materials were used for calculation. The system also moved to Java, Malaya, and other East Indian Colonies along with the business people which is evidenced from some available inscriptions. The use of decimal place-value in lower to higher order with word-numerals and higher to lower order with numerical-symbols were in practice. For calculation on a *pāṭh*, numerical symbols were used, but for writing or copying a manuscript, final results were written in word numerals to avoid confusion in decoding a symbol and also to keep rhythm in verses in which it was written. The zero in many places of *Bakhshālī Ms* (AD 400) has been used as a round symbol (*śunya*, 0). It also came out as dot (.), may be, that thick tip of pen used for circle became dot in the process. This is distinctly visible in *Bakhshālī Ms* and Kashmirian *Atharvaveda*. Bīrūnī (c. AD 1020), has incidentally referred to two system of notation of numbers, namely alphabetic (*abjad*) system (*Huruf al-jummal* or *Hiṣab al-jummal*) and the Indian numerals (*al-Arqam al-Hind*). He has recorded Indian numerals

of nine symbols, and zero as dot in the *Kitab al-Tafhim* (The Book of Instruction in the Art of Astrology). He also referred to circular symbol (0) of the Indians. Al-Khwārizmī (AD 825), another Central Asian scholar, writes about Indian numerals' thus, 'The beginning of the order is on the right side of the writer, and this will be the first of them consisting of unity. If instead of unity they wrote X, it stood in the second digit and their figures was that of unity, they needed a figure of ten similar to the figure of unity so that it became known that this was X, and they put before it one digit and wrote in it a small circle "0", so that it would indicate that the place of unity is vacant'. The Indian name *śunya* was taken over by the Arabs as *aṣ-ṣifr*. This was subsequently changed to *zephirum* (1202-Fibonacci), *tziphra* (1340, Planudes) and *zenero*, *zepiro* (sixteenth-century Italy).

Astronomical Features

The fire sacrifices including construction of fire altars appearing in the *Samhitās*, *Brāhmaṇas* and the *Śrauta sūtras* clearly indicate that *agnihotrs* were concerned mainly with directions for laying the sacrificial fires, new and full moon, the season and accurate calculation of the times of the year etc. The fixation of east-west and north-south lines was considered very important for the construction of altars. Kātyāyana says that eastern and western shadow-points of a central pole in a circle on equinoctial day fix the east-west line and the line perpendicular to that gives the north-south line. The *Śatapatha Brāhmaṇa* reports that Kṛttikā never deviated from the east. R.N. Apte, the well-known vedic scholar feels that east point was verified by the rising point of Kṛttikā in the vedic period. The vedic people took Sun as the sole light giver of the universe, the cause of the seasons, winds, controller and the lord of the world. The Moon was described as *sūryaraśmi*, one which shines by the Sun's light. Different phases of the Moon: viz. *rākā* (full-moon day), *anumati* (preceding full-moon day), *kuhu* (next full moon day), *śinivāli* (preceding new moon day), etc. was known. The *Taittirīya Brāhmaṇa* gives a full list of names of 15 days of the light half (*pūrva pakṣa*) and also of dark half (*aparapakṣa*). The day was called *vāsava* or *aha* and reckoned from sun-rise to sun-rise. The day was further divided into different parts. The period from one moon-rise to the next or from one moon-set to the next was known as *tithi*, which is somewhat different from the present concept of *tithi* of fixed time. That the phenomenon of new and full-moon is related to Moon's elongation from the Sun was also correctly guessed. The invisibility of the Moon on the new-moon day is explained by its being swallowed by the Sun and its appearance by its being released by the Sun.

Nakṣatras, Months, Names of Seasons and New Year

The *nakṣatras* or the group of stars near which the Moon could be seen are the conventional division or marker of the ecliptic (the path) which is followed by Moon, Sun and the planets. The Moon returns to the same position in more than 27 days but less than 28 days. There is mention of 28 *nakṣatras* in early *Samhitās*, *Atharvaveda* and others, but the numbers were reduced to 27 from the time of *Vedāṅga Jyotiṣa*. The names of these *nakṣatras* with their presiding deities are enumerated in the *Yajurveda* beginning with *Kṛttikā*. The lunar (or synodic month) was measured from full-moon to full-moon or from new-moon to new-moon (TS. 7.5.6). The *Taitt. Samhitā* (5.6.7) refers to 12 or 13 lunar months of year and calls the 13th (intercalary) month by the names *saṃsarpa* and *aṃhaspati* (TS. 1.4.14). The six *ṛtus* in solar year with names of 12 tropical months are in *Taitt. Samhitā* (4.4.11.1) and *Vājasaneyī Samhitā* (13.14). Studies have already been made on *Rohiṇi*, *Kṛttikā*, *Bharanī* and *Aśvinī* legends by Tilak, Shamasastri, Sengupta, Dikshit, Kupannaswamy Sastry which indicate that the reference point on the ecliptic on equinoctial day (when day and night were equal) shifted to asterism *Rohiṇi*, *Kṛttikā* (*Samhitā* Period), *Bharanī* (*Vedāṅga Jyotiṣa* Period), *Aśvinī* (*Sūrya Siddhānta* Period) in course of time. A seal from the Mohenjo-daro (M. 2430) corroborates the *Kṛttikā* legend⁸ which supports that the New-Year started from *Agrahāyanī* after the full moon at *Kṛttikā*. By the time of *Kauśītaki Brāhmaṇa* (19.8) the New-Year started with the winter solstice (shortest day) and it was on the new-moon day of Māgha. This indicates that the *puṇimānta* system (from the termination of full-moon) changed to *amānta* system (from the termination of new-moon) with time and the effort went on to synchronize lunar month with the beginning of the tropical year and seasons.

<i>Nakṣatras (Nirayana Longitude)</i> (<i>Taitt. Sam.</i> 4.4.10 <i>Athar. Ved.</i> 19.10)	<i>Lunar Months</i>	<i>Solar Months & Seasons</i> (<i>Taitt. Sam.</i> 4.4.11 <i>Vāj. Sam.</i> 13.14)	
1. Kṛttikā (Alcyon, 36° long)	Kārtika	Urja	Śārada (Autumn)
2. Rohini (Aldebaran, 46°)			
3. Mṛgaśīrsa (λ Orionis, 60°)	Agrahāyanī	Saha	Haimanta (Dewy)
4. Ārdra (Betelgeuse, 65°)			
5. Punarvasu (Pollux, 90°)			

6. Puṣyā (δ Cancrī, 105°)	Pauṣa	Sahasya	
7. Āśleṣā (Hydras, 109°)			
8. Maghās (Regulas, 126°)	Māgha	Tapa	Śuśīra (Winter)
9. (Pūrva) Phalguni (δ Leonis, 138°)	Phalguni	Tapasya	
10. (Uttara) Phalguni (Denebola, 148°)			
11. Hastā (δ Corvi, 170°)			
12. Citrā (Spica, 180°)	Caitra	Madhu	Vasanta (Spring)
13. Svātī (Arcturus, 181°)			
14. Viśākhē (α Centauri, 216°)	Vaiśākha	Mādhava	
15. Anurādhās (δ Scorpi, 219°)			
16. Jyeṣṭhā (Antares, 226°)	Jaiṣṭha	Śukra	Griṣma (Summer)
17. Mūlā (λ Scorpi, 241°)			
18. (Pūrva) Āṣādhās (δ Sagittarii, 241°)	Āṣāḍa	Śuci	
19. (Uttara, Āṣādhās (σ Sagittarii, 259°)			
20. Abhijit (Vega, 262°)			
21. Śravanā (Altair, 278°)	Śrāvaṇa	Nabha	Varṣā (Rainy)
22. Śraviṣṭhās (β Delphini, 293°)			
23. Satabhisā (λ Aquarii, 318°)			
24. (Pūrva) Proṣṭhapadās (Markob, 330°)	Bhadrapadā	Nabhasya	
25. (Uttara) Proṣṭhapadās (γ Pegasi, 346°)			
26. Revatī (ε Piscium, 356°)			
27. Āśvayujau (β Arietis, 10°)	Āśvina	Isa	Śārada (Autumn)
28. Bharanīs (41 Arietis, 25°)			

Luni-Solar Adjustments and Time Units

The natural means of measuring a year originated from the experience of periodic recurrence of climatic seasons. Likewise, the natural means of measuring a day was the period between two consecutive sun-rises and that for a month a period between two full-moons. The return of the Sun to the same position with respect to the fixed star might have appeared to be much more reliable than the slow seasonal variation of the length of day light. There appears to be a constant attempt at adjusting the lunar month with the season. The *Taittirīya Saṃhitā* (7.2.6) mentions how 11 days ceremony (*ekādaśarātra*) were performed after lunar year of 354 days to make up with the seasons (*ṛtus*), i.e. with the sidereal year of 365.25 days. The idea of intercalating a month at regular intervals of time or of adding of 5 or 6 days in one month or more months was thus developed. Naturally, three units of time measurement viz. the solar day, the lunar month, and the solar year are involved. Consequently the luni-solar adjustments⁹ depended on the problem of finding the integers x, y, z which satisfy the relation, x years = y months = z days. The *R̥gveda* gives two years (*Samvatsara*, *Parivatsara*), *Taittirīya Brāhmaṇa* (1.4.10) mentions four years (*Samvatsara*, *Parivatsara*, *Idāvatsara* and *Anuvatsara*). Shamastry also believed in a four year cycle, first 3 years of 360 days and 4th year of 381 days totalling 1461 days in 4 years cycle which gives one year = $1461/4 = 365\frac{1}{4}$ days. The *Vedāṅga Jyotiṣa*, gives (both *R̥gvedic recension*—*Ārca Jyotiṣa*, 36 verses, and *Yajurvedic recension*—*Yājñuṣa Jyotiṣa*, 43 verses) a 5-year cycle, the number of sun-rising, moon-rising, *tithi*, *nakṣatra*, the new-moon, full-moon, account for solstices, seasons, Sun's northward and southward journey, increase and decrease of day-lengths during these journeys, rules for determining the beginning of the season, etc. It prescribes 5 solar years = 62 sidereal months (Moon's revolution) = 67 lunar months (synodic) months. In this cycle of 5 years, solar days = $5 \times 12 \times 30 = 1800$, civil days (solar rising) = 1830, sidereal days (solar rising plus solar cycle, earth's rotation) = 1835. A five year was conceived as *yuga* in *Vedāṅga Jyotiṣa*. The conception of *Caturyuga*, and *Kalpa* were later developments. The *Vedāṅga Jyotiṣa* (Y-VJ, 24) also gives time units (measured by water clock), 1 *āḍaka* = 50 *palas*, 1 *kuḍava* = $\frac{1}{16}$ *āḍaka* = $\frac{3^1}{8}$ *palas*, 1 *nāḍikā* = 200 *palas*— $\frac{3}{16}$ *āḍakas* = 4 *āḍakas*— $\frac{3}{16}$ *āḍakas* = $\frac{61}{16}$ *āḍakas* = 61 *kuḍavas*, 1 *nāḍikā* = $10\frac{1}{20}$ *kalās*, 60 *nāḍikās* = 30 *muhūrtas* = 1 day.

Astrological Tradition

The *Atharva Jyotiṣa* (in 14 chapters, 162 verses) attached to *Atharvaveda* tradition deals with the *Muhūrta* branch of astrology. *Atharvaveda* says that

it was taught by Pitāmaha to Kāśyapa. The *muhūrta* as a time unit comes first in the *Śatapatha Brāhmaṇa* (12.3.2.5) which gives 1 *divasa* = 30 *muhūrtas*, 1 *muhūrta* = 15 *kṣīpras*, 1 *kṣīpra* = 15 *itarhis*, 1 *itarhi* = 15 *idānis*, 1 *idāni* = 15 *prāṇas*. The *Atharva Jyotiṣa* gives the unit as *ahorātra* (whole day), *muhūrta*, *truṭi*, *kalā*, *lava*, former being 30 times the next instead of 15 times. The last unit is *nimeśa* (1 *lava* = 12 *nimeśa*). Reference to 7 planets, Sun, Moon and five planets are found. The *Atharvaveda* (19.9) writes, 'May the Candramasa and Āditya *graha* along with Rāhu prove auspicious to you'. The *Atharva Jyotiṣa* also gives names of 7 week days with names of planets and describing planets as 'Lord of the days'. The names are *āditya* (Sun), *soma* (Moon), *bhauma* (Mars), *budha* (Mercury), *brhaspati* (Jupiter), *bhārgava* (Venus) and *śani* (Saturn). In other places it has also used names of planets as being applicable to planets like *sūrya* (Sun), *lohitāṅga* (Moon), *somasuta* (Mercury), *devaguru* (Jupiter), *bhṛgu*, *śukra* (Venus), *sūryasuta* (Saturn). This also contains the seeds of prediction of *Jātaka* astrology expressing fears, woes and horrors when certain *nakṣatras* are accompanied by planets, meteors (*ulkā*), etc. The *Aśvālayana Sūtra* contains instructions like fields should be ploughed on the *Uttara Proṣṭhapāda*, (*Gṛhyasūtra*, 2.10.3), 'thread ceremony should be performed on auspicious *nakṣatras*' (*Gṛhyasūtra*, 1.4.1) etc. The words, *muhūrta* and *kṣaṇa* also appear in the *Nirukta*. The *Yājñavalkya Smṛti* gives the names of 9 planets (7 planets, Rāhu and Ketu) (*Ācāradyāya*) and 12 parts of the ecliptic (*rāśis*) in order to find proper times (*Sūrya-Samkrama*) for performing the *Śrāddha*. The *Yavana Jātaka* of Sphujidhvaja¹⁰ (AD 269) is considered as a major work carrying Greek influence. But it has also used (last chapter) time units viz. *palas*, *kuḍavas*, *liptās*, *nādikā*, *kalā*, *muhūrta* (or *kṣaṇa*) same as *Vedāṅga Jyotiṣa*, with the exception that it has used 1 *nādikā* = 10 *kalās* instead of $10\frac{1}{20}$ *kalās* used by *Vedāṅga Jyotiṣa*, possibly to avoid fraction. It has conceived a cycle of 165 years instead of 5 years and has given the number of solar months, solar days, civil days, intercalary months, *tithis*, omitted *tithis*, sidereal months and other elements for this cycle. The *Brhājātaka* (or *Brhat Jātaka*) is the next most important work on astrology by Varāhamihira (c. AD 505) who also composed *Brhat Jātaka* (horoscopic work) and three smaller works on marriage and *yātrā* (journey) on astrology, besides collection of five important works on astronomy (*Pañcasiddhāntikā*). Varāhamihira referred to Parāśara (twice), Māṇḍavya, and *ācaryas* like Satya, Maya, Yavana, Manithya, Jivasarmā, Viṣṇugupta (identified as Cānakya Viṣṇugupta, the minister of Candragupta by the commentator). Bhaṭṭotpala (c. AD 966), the commentator on the *Brhat Jātaka* has given astrological quotations from the works of Gārgī, Badarāyana, Yājñavalkya and Māṇḍavya. The *Brhat Jātaka* contains 36 Greek words namely, the 12 signs—*Kriyā*,

Taburi, Jituma, Kulir, Leya, Pāthēna, Jūka, Kaurṭya, Tauksika, Akokera, Hridroga, Ittham and 24 other words including the words, *Liptā, Horā, Dreskāna, Kendra, Koṇa*, etc. On the basis of these terms, Weber and Kern believe that there were Greek influence on Indian astrological works. Large number of late astrological works on *Jātakas* (*Kalacakra Jātaka, Gauri Jātaka, Minarāja Jātaka, Jātakasāra* of Nṛhari, *Sārāvalī, Jātaka Paddhati*, etc.) dealing with misery and woe based on ascendants and descendants of planets, *Horās* (by Vaśiṣṭha, Garga, Parāśara, Varāha, Lalla, Nārada, etc.) dealing with whether an event will happen at all, if so when and how on the basis of horoscope cast, *Muhūrtas* (*tithis, nakṣatras* prohibited for auspicious ceremony, taboos, etc.), *Pāśaka Vidyā* (questions answered according to the casting of dice), *Tājik* (forecasting as per ascendant and descendant of planets), etc. were in vogue.

Yuga, Kalpa and Mahāyuga

The *Vedāṅga Jyotiṣa* had a cycle of 5 years in a *yuga*. The *Yavana Jātaka* had 165 years cycle. The *Pāṇini*, though refers to *yuga* and *kali*, it is *Manusmṛti* which gives 4 *yugas* (*Kṛta, Tretā, Dvāpara* and *Kali*) = 12,000 divine years = 4,320,000 ordinary human year, since 1 divine year = 360 ordinary years. The *Mahābhārata* also had the same *yuga* and time units as that of *Manusmṛti*. The *Siddhāntic* astronomy, unlike Greek astronomy, have established an epoch when all planets were in zero longitude. Āryabhaṭa I considered an epoch when the Sun, the Moon, Mars, Mercury, Jupiter, Venus and Saturn were last in zero longitude at sunrise in Laṅkā (a hypothetical place at the intersection of the equator and the meridian of Ujjain) on 18 February, Friday, 3102 BC. The period of one such epoch to the next, according to Āryabhaṭa I is 1,080,000 years. When the Moon's apogee and the Moon's ascending node are included in the list of the planets, the above mentioned period (*Mahāyuga*) becomes 4,320,000 years which is defined as the duration of the *yuga*. The *yuga* is a period of time which begins and ends when the Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, the Moon's apogee and the Moon's ascending node are in zero longitude. It consists of 4 periods, *Kṛta, Tretā, Dvāpara* and *Kali*. The current quarter *yuga* is the current *Kaliyuga* which is assumed to have began at sunrise at Laṅkā on Friday, 18 February, 3102 BC. A bigger period than the *yuga* is called *Kalpa*. According to Āryabhaṭa I, *Kalpa* consists of 1008 *yugas*, and $459\frac{3}{4}$ *yugas* had elapsed at the beginning of current *Kaliyuga* since the beginning of current *Kalpa*. The main difference in Āryabhaṭa, Sūrya-Siddhānta and Brahma Siddhānta School is that the length of the year and motion of planets in a

Kalpa and *Mahāyuga* is different and other elements are same. There is also a difference of opinion as to the starting of *Kali* era on 18 February, Friday, 3102 BC which needs more careful scrutiny. The Hindu astronomical works called *Siddhānta* adopt the terms of creation as the epoch of calculation whereas those called *Tantra* adopt the beginning of *Kaliyuga* as the epoch of calculation.

Old Siddhāntic Tradition

The Jains made positive contributions to mathematics. A few works like *Sūrya Prajñapti*, *Candra Prajñapti*, *Jamboo Dvīpa Prajñapti*, *Sthānāṅga Sūtra*, *Bhagavatī Sūtra*, *Anuyogadvāra Sūtra* are available to us. It deals with problems dealing with circle, chord, circumference, π ($=\sqrt{10}$), diameter, arc, segment, big numbers, infinity, laws of indices, symbols, operations etc. Varāhamihira was born in AD 505 in the village of Kapithaka (Farrukhabad District of Uttar Pradesh) and moved to Ujjain. His forefathers migrated to India from Maga country in Persia and settled in the Kapithaka. He quoted Āryabhaṭa I several times and compiled *Pañcasiddhāntikā*, i.e. five *Siddhānta* works namely, *Paulīśa*, *Romaka*, *Vaśiṣṭha*, *Saura* and *Paitāmaha* besides astrological works. Colebrooke (1807–17), Whitney and Burgess (1860), Kern (1865), Thibaut (1890) and a few other European scholars expressed opinion on the relative importance and origin of Indian astronomy. Thibaut in his introduction to the *Pañcasiddhāntikā* observes that the *Paitāmaha Siddhānta* (c. AD 80) is the oldest and carries prescientific stage of astronomical knowledge. The *Vaśiṣṭha Siddhānta* written prior to AD 269 is more advanced. The *Romaka*, and *Paulīśa* have Greek influence. The *Saura Siddhānta* only contains new features. During the early centuries of the Christian era the Indians were in touch with the Greeks, Romans and other scholars and those of Babylonian and Greek knowledge may have been available to them.

The scholars like Dikshit, Sengupta, Ganguly, Kuppannaswamy and Shukla¹¹ testified that the refinements introduced by Ptolemy (AD 150) and even Hipparchus (150 BC) remained unknown to India. Whatever Greek influences are there, they are all of pre-Ptolemaic period and possibly of pre-Hipparchus time. The extent and the nature of contact were through conferences or the direct borrowal through translation of texts is still to be investigated. Neugebauer has shown that the *Vaśiṣṭha* and *Paulīśa* were inspired by Babylonian linear astronomy.

The *Pañcasiddhāntikā* (Five Siddhāntas) were known to India from first century AD to fifth century AD. By this time, the Indians had already acquired the knowledge of zero and decimal place-value, eight fundamental opera-

tions of arithmetic—addition, subtraction, multiplication, division, etc., rule of three, inverse rule of three, knowledge of combinations of six savours (a, b, c, d, e, f), 2 at a time, C (6, 4)—ab, ac, ad, ae, af, bc, bd, be, bf, cd, ce, cf, de, df, ef—15 in all), 3 at a time C (6, 3), 4 at a time C (6, 4) was known. Likewise, the knowledge of binomial expansion for calculating the shortcomings in metrical rhythm of music based on *long* (a) and *short* (b) sounds were known. Or in other words binomial expansion like $(a + b)^2 = 1.a^2 + 2a.b + 1.b^2$, $(a + b)^3 = 1.a^3 + 3.a^2b + 3.ab^2 + 1.b^3$, $(a + b)^4 = 1.a^4 + 4.a^3b + 6.a^2b^2 + 4.ab^3 + 1.b^4$ and achieved various other mathematical results. These undoubtedly brought great change in the Indian scenario in the field of mathematics and astronomy. The development of algebraic and trigonometric tools also revolutionised the calculations and methods in astronomy. A series of writings came in with Āryabhaṭa I (*Āryapakṣa* School), Lāṭadeva, the student of Āryabhaṭa I and author of revised *Sūryasiddhānta* (*Sūryapakṣa* School), Brahmagupta (*Brahmapakṣa* School), Bhāskara I (AD 628), student of Āryabhaṭa School and a host of other scholars namely Lalla (c. AD 749), Vaṭeśvara (AD 904), Āryabhaṭa II (AD 950), Śrīpati (AD 1039), Bhāskara II (AD 1150), and others. Āryabhaṭa I, an Āsmakīya (Keralian) lived in Magadha (modern Bihar) and wrote his *Āryabhaṭīya*. Magadha in ancient time was a great centre of learning and is well known for famous university at Nalanda (situated in modern district of Patna). There was a special provision for study of astronomy in this university. Āryabhaṭa I is referred to as *Kulapa* (= *Kulapati* or Head of a University) by the commentator.

Āryasiddhānta and Āryabhaṭīya of Āryabhaṭa I (AD b. 496)

The *Āryasiddhānta* of Āryabhaṭa I is only known from the quotations of Varāhmihira (AD 505), Bhāskara I (AD 600), and Brahmagupta (AD 628), in which the day begins at midnight at Laṅkā. The *Āryabhaṭīya* begins the day with sun-rise on Sunday Caitra-Kṛṣṇādi, Śaka 421 (AD 499). A summary of contents of *Āryabhaṭīya* will give an idea how the knowledge exploded. Under arithmetic, it discusses alphabetic system of notation and place-value including fundamental operations like squaring, square-root, cubing and cube-root of numbers. The geometrical problems deal with area of triangle, circle, trapezium, plane figures, volumes of right pyramid, sphere, properties of similar triangle, inscribed triangles and rectangles. The theorem of square on the diagonal, application of the properties of similar triangles. The algebra has concentrated in finding the sum of natural numbers (series method), square of n-natural numbers, cubes of n-natural numbers, formation of equation, use of rule of three for application (both direct and inverse

rule), solution of quadratic equation, solution of indeterminate equation [$by = ax + c$, $x = (by - c)/a$] where solution of x and y were obtained by repeated division (*Kuṭṭaka*, *kuṭ* means to pulverize), etc. In trigonometry, *Jyā* (R Sine) is defined, and 28 *Jyā* table at an interval of $3^{\circ}45'$ ($R = 3438'$) was constructed, the value of $\pi = 3.1416$ was found to be the correct to 3 places of decimals. Āryabhaṭa I's value of $\pi = 62832/20000 = 3 + 1/7 + 1/16 + 1/11$. Successive convergents are 3, 22/7, 355/113, 3927/1250 which were used by later astronomers. In astronomy, three important hypothesis were made viz. (1) The Mean planets revolve in geocentric circular orbits, (2) The true planets move in epicycles or in eccentrics, (3) All planets have equal linear motion in their respective orbits.

The knowledge of indeterminate equations played a significant role. The method of indeterminate equation was a successive method of division. The same method is possibly used for value of π , solution of first degree and second degree indeterminate equation. It was also used to determine the mean longitude of planet for mean longitude = $(R \times A)/C$, where R = revolution number of planets, A = *ahargana* = number of days since the epoch and C = number of days in a *yuga* or *kalpa*. Large number of astronomical problems of Bhāskara I are changed to $(ax - c)/b = y$ where x = *ahargana* and y = Sun's mean longitude.

Astronomical Corrections and Astronomical Instruments

The geocentric longitude of a planet is derived by the mean longitude by the following corrections.

- (1) Correction for local longitude (*deśāntara correction*).
- (2) Equation of the centre (*bāhuphala*).
- (3) Correction of the equation of time due to eccentricity of the ecliptic.
- (4) Correction of local latitude (*cara*) in case of Sun and Moon, and an additional correction (*śighraphala*) in case of other planets.

Besides these, Vaṭeśvara (904) gave the lunar correction which gives deficit of the Moon's equation of centre and evection. Bhāskara II (1150) gave another correction, variation. Mañjulā (932) used a process of differentiation in finding the velocity of planet. All Siddhāntic astronomy gave the method and time of eclipse, along with *tithi*, *nakṣatra*, *karaṇa*, *yuga*, since these had important bearing on religious observations.

A large number of astronomical instruments were referred to and used. To cite a few from Lalla's *Śiṣyadhivṛddhida*¹² (c. AD 700–1000 centuries),

these are (1) Air and water instrument, (2) *Gola-yantra*, (3) Man with a rosary of beads, (4) Self-rotating wheel, and self rotating spheres, (5) *Cakra yantra* (circle), (6) *Dhanur yantra* (semi-circle), (7) *Kartari yantra*, the scissors, (8) *Kapāla yantra* (set horizontally on the ground and its needle vertical), (9) *Bhagaṇa yantra*, (10) *Ghaṭi yantra* and conversion of observed *ghaṭis* into time only, (11) *Śaṅku yantra*, (12) *Śālākā yantra*, needle, (13) *Sakaṭa yantra* (for *tithi* observation), (14) *Yaṣṭhī yantra* and graduated tube (for Altitude, Zenith Distance and Bāhu) and others.

The Extension of Knowledge by Kerala Astronomers

The knowledge of *Jyā* (or *Jīva*), *Kojyā* and *Śara* for a planet in a circle of known radius (*Trijyā*) was used. The scholars used gradually improved value of (*Trijyā*) where $\text{Sinus totus} = 24^{\text{th}} \text{ } Jyā = R = 3438'$ (Āryabhaṭa I), $120'$ (*Pañcasiddhāntikā*), $3270'$ (Brahmagupta), $3437' 44'' 19''$ (Govindasvāmī, AD 850), $3437' 44'' 48''$ (Mādhava c. AD 1400). From the relation $c = 2\pi r$, where c = circumference and r = radius of the circle, r was calculated. The value of C was taken as $C = 360 \text{ degrees} = 21600 \text{ minutes}$ and $\pi = 3.1416$ (Āryabhaṭa I). Mādhava (c. AD 1400) used a value of π correct to 11 places of decimals. Mādhava used knowledge of series to approximate the value of *Jīva* $= s - s^3/3!r^2$, and *Śara* $s^2/2!r$ for an arc s of radius r and applied them repeatedly.

Important trigonometrical relations were also found by scholars from Āryabhaṭa I onwards. The successive approximation¹³ of Mādhava and other Kerala astronomers led, for $s = rx$, to the discovery of

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots$$

$$\sin x = x - \frac{x^2}{2!} + \frac{x^4}{4!} - \dots$$

These were investigated and rediscovered later in Europe.

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Scientific Tradition in India (3400–1500 BC)

S.R. RAO

Pure science is knowledge acquired in the pursuit of knowledge itself, as distinct from technology which may be defined as a body of knowledge, the application of which or potential application, is considered to meet the desires or wants of society. But science and technology by themselves do not satisfy all the desires or needs of man. For instance, the aesthetic urges of man in the field of fine arts and literature, generally included among humanities, or the desire to look for a superhuman force to bring relief when all the tools of science and technology known in a given society fail to do so, are not met by science and technology. Technology is directed outward to satisfy some of the inner desires of man but not all. Humanism, on the other hand, concerns the nature of the desires themselves and attempts to find a solution either by regulating the process of fulfillment or by self-conviction of the individual or society that a certain amount of restraint is essential in seeking pleasure. This restraint, physical, moral and mental, is in the interest of the society as well as the individual as conceived by our ancestors. To exercise the restraint voluntarily and not through force from the state, they evolved a unique system of disciplining the mind as well as the body known as *yoga*. This is one of the important contributions of the Indus Civilization.

Humanism is not a body of knowledge *per se*, but an awakening of the human potential to transcend the material world and achieve an inner satisfaction. This does not, however, mean that man is not interested in material comfort at all, as is often said in the case of Indians whose Upaniṣadic

thought explored the higher regions of human mind. The process of awakening the human potential culminated in *yoga* early in the Indus Civilization (2500 BC) to which further reference will be made shortly.

Popogounous, a modern historian of science, while discussing the philosophical presuppositions of the interaction among the sciences feels that the problem of the interaction among the sciences is essentially the question of the epistemological status of each science, that is, whether each particular science is granted thematic, methodological and theoretical integrity, or whether each science is viewed as in a complementary relation to other sciences and as being a part of the general cognitive activity of man which is composed not only of the sciences, but also of philosophy, the arts and practical and social human activity.

Both the above attempts to specify what science is, are partial, for, 'science is a social phenomenon'.

SCIENCE AND ARCHAEOLOGY

Science is, no doubt, a systematic activity directed at the increase of knowledge, but it is not the only such activity. Practical human activity constitutes as much a source of the knowledge of the world and its processes as does the application of the theoretical formulations of science. Thus, science cannot be considered in isolation either from the other sources of knowledge or from the priorities that the social context establishes concerning the course of investigation. It is here that archaeology comes to play a very important role. Being concerned with man's every practical activity through which it delves into the theoretical aspects also to some extent, it makes stage by stage revelation of the development of man as an intelligent being and reviews his achievements and failures through the ages taking into account his environment also. In the process it supplies relevant data needed for the reconstruction of the history of science and technology, e.g. history of mathematics, physics, chemistry, astronomy, botany and the development of technology such as engineering, mining and metallurgy, navigation and ceramics. To a large extent it is archaeology which digs up the past and furnishes data. It acts as a bridge between science and humanism.

To understand the thought process of man ever since he became a 'knowing man' with a large brain, which is the most sophisticated instrument created within the skull, it is essential to study all his activities through the artefacts he has left behind. About ten thousand years ago he became a food producer and tried to settle down in small groups tending the crops. Such

groups developed into villages. Science and technology made rapid progress with surplus food production which could sustain craftsmen such as the potter, boat builder, metallurgist, lapidary and the like. India has the unique distinction of making progress in the material and spiritual fields simultaneously with a view to increase knowledge of one's environment and the cosmos itself. The achievement of the present society is the result of accumulated knowledge.

BEGINNING OF SCIENTIFIC TRADITION

The earliest civilization of India, namely the Indus Civilization, also known as the Harappa Civilization, laid the foundation of scientific thought and developed scientific temperament of mind in the true sense of the term. The Harappans were the most disciplined people in the third millennium BC. This discipline visible in all walks of their life was the result of the science of yoga which they developed over the centuries. This is one of the enduring contributions they have made to the progress of mankind in the material and spiritual fields. Another lasting contribution of the Harappans is the simplified alphabetic system of writing, without which quick communication and recording of thought would not have been possible. With the recording of accumulated knowledge and experience, science, philosophy, fine art and the very art of living took long strides in the direction of providing physical comfort and increasing intellectual activity. The spirit of inquiry and adventure sent them to distant lands across the oceans. It was again the Harappans who became pioneers in studying tides, waves and currents and put their knowledge to practical use to build the first tidal dock of the world at Lothal. This was their great contribution to maritime activity.

Although towns and cities were built in Egypt and Sumer also, they were not well planned. The Harappans developed town-planning as a science demarcating specific areas for industries, commercial activity, residences of the ruler and ruled and for workers in granaries, bead factories, dock and warehouse (Fig. 1). Another significant contribution was the science of hydrology (Fig. 2) which enabled them to keep the cities and towns meticulously clean. Efficient administration coupled with high civic sense of the residents who worked for the common good ensured orderliness, cooperation with the administration and a sense of belonging. The standardization of goods and services throughout the vast territory extending over 1.5 million square kilometers was no mean achievement of an administration which believed in adopting peaceful means to bring about uniformity in planning towns, enforcing municipal and trade regulations and in the production of

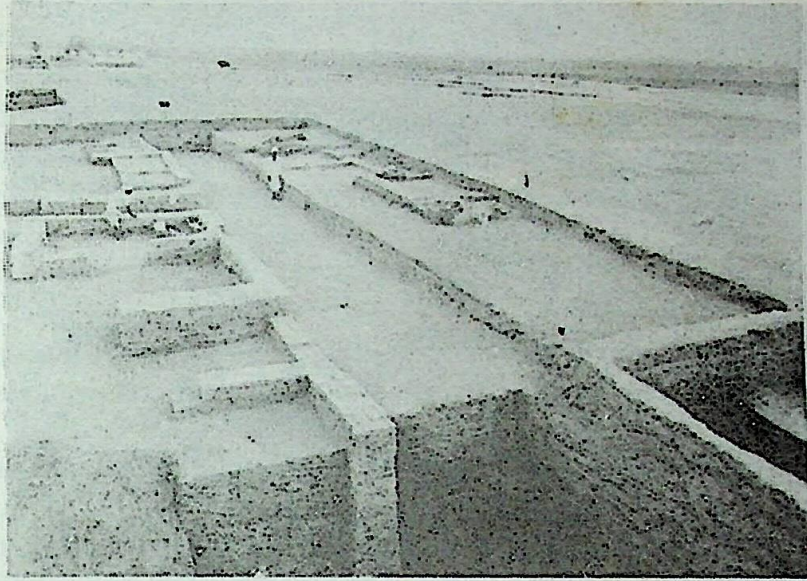


Fig. 1. Lothal: Bazar Street in Lower Town flanked by coppersmith's workshop (figure on left) and shell-worker's house (right). The township is built on a platform of mudbrick and mud.

goods to a required standard. There is no evidence of any large army, much less any invasion of cities and provinces, which was quite common in the Sumerian Civilization. The far-flung trade of the Indus Civilization aimed at procuring unavailable raw materials from Bahrain, Oman, Mesopotamia (Iraq), Afghanistan, Elam (Iran) and Syria resulted in the establishment of merchant colonies which exchanged not merely goods but also ideas. The Harappan weight system and writing were adopted in Bahrain. Of far-reaching consequence was the borrowing of the Harappan cursive script by the Semitics for their consonantal writing. To the Semitic consonantal system the Greeks added a few vowel signs and completed an alphabetic system of consonants and initial vowels. The Harappans evolved from a partly pictorial writing a cursive alphabetic writing of consonants and a few initial and medial vowels, which became the basis of Brahmi and other ancient Indian scripts. The decoded Harappan script has thrown a flood of light on the religion and polity of the Indus Civilization. The writing on seals gives a clue to their conceptual thinking about the source of energy, cosmic and moral order, sacrifice and cosmology. It was the Harappans who laid the foundation of Vedic religious thought, philosophy and culture. The general observations made above will be substantiated below by specific examples from the scientific, spiritual and cultural activities of the Harappans.

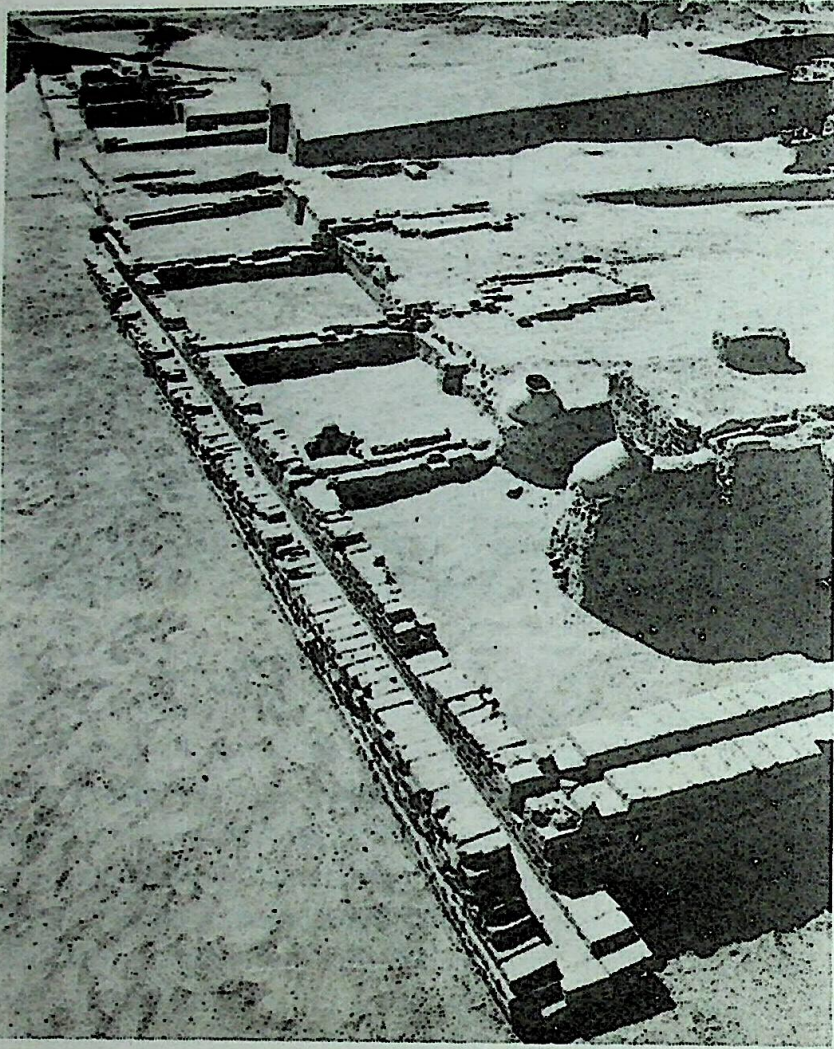


Fig. 2. Lothal: The science of hydrology developed by the Harappans as attested to by public sewers and private drains. Private baths were connected to underground sewers through runnels.

In presenting the achievements of the Indus Civilization in the field of science the social and reflective manifestations of its culture will also be taken into account to avoid presentation of a fragmented human experience and knowledge.

MYTHS AND LEGENDS

A historian by definition is a collector of facts, but he is also a scientist in search of laws governing social growth and development and a philosopher growing beyond these laws to find a system and order. In the case of ancient Indian history and scientific thought, facts are supplied by archaeology. The

archaeologist cannot, however, ignore myths and legends totally. He has to explore and collect evidence to verify the truth contained in myths and legends, for, they often tell the truth in a poetic form embroidered with some sacred beliefs. Although the modern mind has interpreted mythology 'as a primitive fumbling effort to explain the world of nature' (Frazer), a more serious study of myths by Ananda K. Coomaraswamy confirms that 'myths are the vehicle of man's profoundest metaphysical insights'. In fact, the so-called 'Dark Age of Indian History' (1900–1600 BC) abounding in myths and legends was a period of great progress in conceptual thinking when the flood-stricken Harappans, who are designated as Late Harappans, migrated to the east and south from the urban centres and lived in small unimpressive villages. It was a period of simple living and high thinking. Although materially the Late Harappans were not as prosperous as their ancestors were in the first half of the third millennium BC. Their literary and scientific output as reflected in the Vedas was not less important for the progress of mankind.

Before going into details of the scientific tradition of India in the third and second millennia (Harappa and Late Harappan Cultures), it is necessary to note the revised and generally accepted dates of the Indus Civilization. Marshal dated the Indus Civilization from 3250 to 2750 BC and Wheeler modified it on the basis of stratigraphy and comparative chronology to 2500–1500 BC. In 1964, D.P. Agarwal advocated a shorter chronology on the basis of 14C dates namely 2200–1700 BC. This, however, had to be further modified on two considerations. First the 14C dates from the recent excavation at Harappa and Mohenjo-daro in Pakistan by G.F. Dales and from other sites in India are much earlier. Second the pre-1500 BC 14C dates themselves were found to be much younger than the more precise dates arrived at by dendro-chronology and the calibration of 14C dates suggested by MASCA has been widely accepted. The following revised dates are taken into account by most archaeologists (Rao S.R., 1991).

MASCA-CORRECTED 14C DATES

Pre-Harappa Cultures

Mehragarh (Chalcolithic), Kot-diji I	3400–3000 BC
Sothi and Kalibangan I	3100–2800 BC

Harappa Culture (Mature)

Mohenjo-daro	3100–1900 BC
Lothal A	3000–1900 BC
Kalibangan II	2900–1900 BC
Rangpur II A	2000–1900 BC

MEASUREMENTS AND WEIGHT SYSTEM

Accuracy in measuring mass, lengths and time is the index to the technological advancement of a civilization. In this respect the achievement of the Harappans is unparalleled. They had developed a good degree of skill in their measuring computational techniques which enabled them to achieve efficiency in town-planning, building docks, granaries, warehouse, drains and private and public baths. Hemmy had concluded that the smaller weights of Harappa and Mohenjo-daro were in the binary system and the larger ones in the decimal system. The present author had separated the hexahedron weights of Lothal (Fig. 3) from the truncated spheroid weights from the same site and argued for two systems (Fig. 4). V.B. Mainkar, however took all the weights of Lothal, Harappa, and Mohenjo-daro and divided them into two logical groups. The unit weight of 27.584 g of the first series is 50 per cent higher than the unit weight 18.1650 g of the second series. Normally there are two basic units in a series. The lower unit is used for weighing small quantities of precious commodities and the higher unit for weighing commodities of daily use, for instance food grains. According to Mainkar, the Indus weight of 27.584 g in the first series was the lower unit weight and 560.70 g or 1417.5 g was the higher unit weight. The smaller denominations are decimal graduation of the lower unit weight, the smallest being 0.05 times the unit. The ratio is 1, 2, 5, 10, 20, 50, 100, 200, 500 etc.

The higher unit weight should not be too heavy to handle, not more than 2 kg. In the case of Indus weight, the ratio would be 20:1 or 50:1, that is 546.70 g or 1417.5 g. Another series of very small weights in the form of gold discs carefully preserved in a building close to the Bead Factory at Lothal, is of great significance not only for its accuracy but also for its conformity with the small weight system of later Indian culture referred to in the *Arthasāstra*. The unit in this series is 100 mg running in decimal graduation

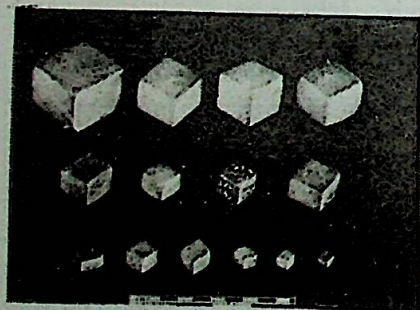


Fig. 3. Hexahedron weights of Lothal made of chert and agate which run in decimal graduation.

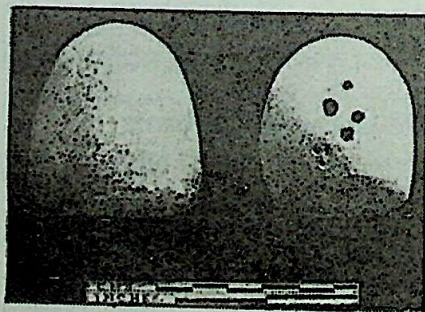
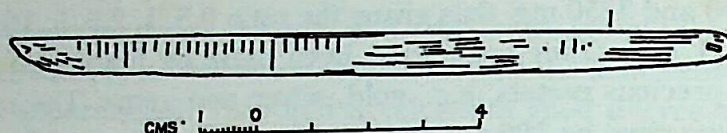


Fig. 4. Truncated spheroid weights of stone mistaken for *linga*.

to a large extent. The discs weigh 50, 100, 250, 500, 1000, 2500, 2750, 2800, 2900, 3000 and 3250 mg, thus giving the ratio 0.5, 1, 2.5, 5, 10, 25, 27.5, 28, 29, 30 and 32.5. They must have been used by Harappan jewellers for weighing precious metals, e.g., gold, silver and gems. The correct weight of the *Gunja* must be 100 mg and not 109 mg as assumed by Mainkar who however admits that the weight of the *Gunja* varies in weight from season to season ranging from 105 to 120 mg. The smallest disc weight is 50 mg equal to half *Gunja* which is called *maśaka/dhānya* in the *Arthaśāstra*. The word *maśaka* occurs in Indus seal-inscriptions also. According to the *Arthaśāstra*, five *Gunjas* are equal to one *suvarṇamaśaka* which corresponds to the Lothal weight of 500 mg. It is interesting to find that the same text prescribes two weight systems, one running in the ratio 0.5, 1, 2, 4, 8 and the other in the ratio 1, 2, 4, 8, 10, 20, 30, 40 and 100. The *karṣa* or *suvarṇa* of the *Arthaśāstra* weighing 8.720 g, is related to the unit in one of the Indus series weighing 8.575 g and the *droṇa* of the same text weighing 69.76 g is related to the 69.03 g weight of the Indus system. The difference may be attributed to the assumption by Mainkar that the *Gunja* weighed 109 g while the more accurate weight of the Indus *Gunja* was 100 mg. The Indus metrology was followed for more than a thousand years in the subcontinent and it is not unlikely that the Greek Uncia of 27.2 g was modelled on the Indus lower unit weight of 27.584 g of the mature Harappan period or the 26.611 g of the Late Harappan period of Rangpur, etc. The logical use of the decimal division introduced by the Harappans found its reflection in the Vedic period (*Yajurveda* Ch. 17, Verse 2).

Linear Measurement

A fragmentary scale of conch shell from Mohenjo-daro has nine graduations. A hollow circle on one graduation and a circular dot on the fifth graduation from the hollow circle are clearly marked. The length between the hollow circle and dot is 33.528 mm. According to Mainkar, the length between two hollow circles would be 67.056 mm. He observes, 'Since the subdivision of the major graduation on the broken scale is decimal, the full scale must have had ten major graduations giving a total length of 670.56 mm'. On the ivory scale (Fig. 5) from Lothal, partly broken, twenty-seven divisions are visible. The sixth and twenty-first graduation lines on this scale are longer than the rest clearly indicating a decimal graduation. The length over the visible twenty-seven divisions is 46 mm, giving an average of 1.704 mm. Though the Lothal and Mohenjo-daro scales appear different because of the smaller divisions on the former, the two are integrated as is apparent from the fact



IVORY SCALE

Fig. 5. Lothal: Partly broken ivory scale in which twenty-seven divisions are visible.

that four divisions of the Lothal scale are equal to one division of the Mohenjo-daro scale (6.706 mm). The smallness of Lothal graduation suggests that the scale was used for finer measurements like measuring seals, inlays, etc. There is no substantial error inspite of the extremely small divisions. The calculated distance of 68 mm in forty divisions of Lothal scale is almost equal to the actual distance of 67 mm on the Mohenjo-daro scale. Even today it is difficult to read with the naked eye graduation lines separated by 1 mm and it must have been difficult to draw such lines four thousand years ago when modern machinery was not available. The practical use of the integrated Indus scale can be demonstrated from the fact that the longest side of the Mohenjo-daro brick measuring 250 mm is equal to 10 major graduations within limits of error. Bricks of Kalibangan measure $400 \times 200 \times 100$ mm (1L: 0.5 B: 0.25 T). The Indus bricks were manufactured in dimensions which were integral multiples of large Lothal graduations. The major public buildings such as the dock at Lothal and the Great Bath of Mohenjo-daro are in multiple graduation of the Lothal scale or the integrated Indus scale. For instance, the width of the brick wall of the dock above the ground being 1.04 m which is equal to forty large graduations on the Lothal scale ($25.56 \text{ mm} \times 40$) and the width of its foundation 1.78 m is equal to thousand times the small graduation (1.704 mm). The width of the doors in Lothal and Mohenjo-daro being 1.02 m, it is forty times the large graduation on the Lothal scale. The other numerous dimensions and measurements reveal the rationality and accuracy of the Indus integrated scale. The Lothal unit of 17.4 mm (in ten divisions) is almost equal to 17.78 mm of the *angula* of the *Arthasāstra* (Mainkar 1984). On this basis the entire series of length measures specified in the *Arthasāstra* agrees with the pattern of Indus scales.

Brij Bhusan Vij, who has calculated the area measures of the Indus civilization observes, 'The Indus Civilization achieved perfection in its mea-

asuring technology and the material evidence suggests that the ideas of the circle and angle and also the ratio between the circumference to the diameter of the circle was known to this culture'. The dimensions to which the Great Bath had been constructed leave no doubt in the mind of the author that the idea of angles and their trigonometric functions were within their speculative imagination (Vij, B.B., 1984). Citing certain facts from Indus buildings and antiquities Vij concludes that 'the Indus civilization certainly knew the realistically exact value for the ratio π (π) and hence the measured dimension of the circumference of the earth was within their technological capability' (Vij B.B., *op. cit.*). The extremely high rating of standardized practices followed in construction technology such as dimension of bricks, width of doors, dimensions of baths, gradients of drains, and width of roads, throughout the vast territory is obvious in all Harappan towns. The Indus Civilization developed the metric-based measurement technology and perhaps the use of decimal science based on 'sexagesimal numeration'. The Great Bath of Mohenjo-daro is said to have been scientifically constructed to calculated dimensions, indicating a keen sense of mathematics and astronomy.

Sextant

Circular ring-like objects of conch shell with 4 or 6 deep slits on both the lower and upper margins cut in alternating positions have been found at Mohenjo-daro, Lothal and Dhola Vira (Kotada). The use of the ring-like object from Lothal was put to test by the Surveyor in the Archaeological Survey of India by measuring angles on a plain surface with the help of this object (Fig. 6). The lines passing through opposite slits were drawn on a plain surface and the angles so formed measured 45° in the case of Lothal object having 8 slits whereas the Dhola Vira object with 12 slits produced angles of 30° . The shell ring of Dhola Vira could be symbolic of the divisions of the Zodiac into 12 divisions of 30° each. A more important use of the instrument by the navigator can be inferred from the fact that the 8 or 12 slits are in sets of 4 or 6 on each margin. The purpose of having slits on 2 margins was not just measuring the line, points and degrees on a plain surface but to measure 8 or 12 whole sections of the horizon and the sky. When viewed simultaneously through opposite slits in the lower and upper margins, the lines so formed help to measure the section of the horizon especially when the instrument is suspended by a thread or wire passing through the central hole in a terracotta disc. Such objects have been found in Lothal and Mohenjo-daro.

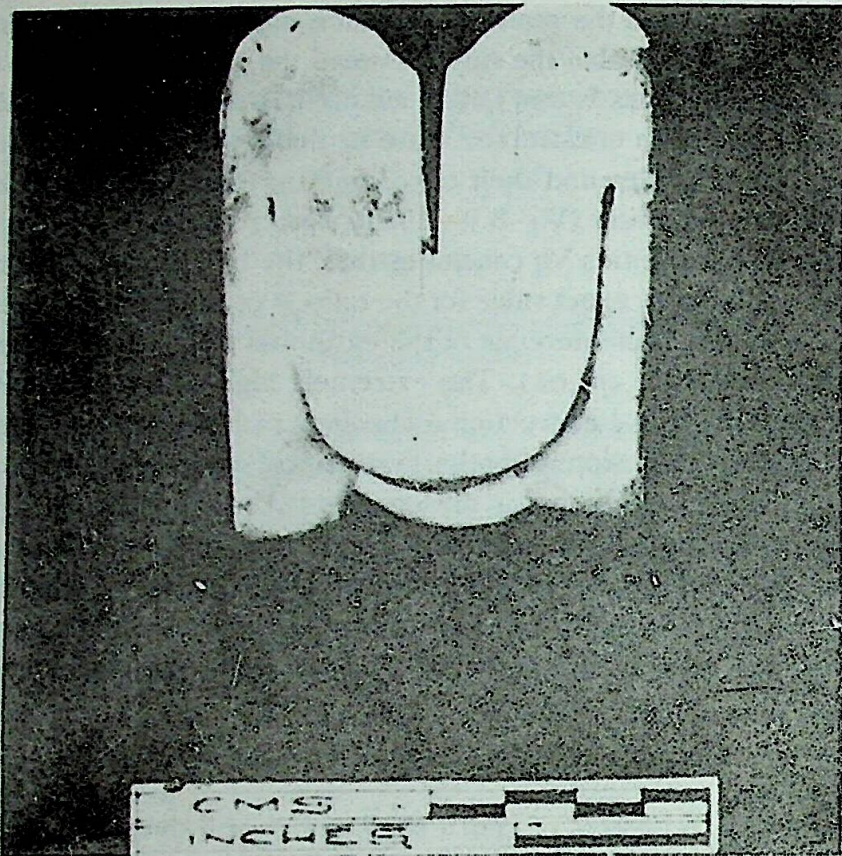


Fig. 6. Lothal: Circular ring of shell with 8 slits used for measuring angles on plain surface and as sextant for measuring whole sections of the horizon.

ASTRONOMY

It appears that 2000 years before the Greeks had thought of an 8-fold or 12-fold division of the sky the Harappans had already achieved it and devised an instrument to measure the angles and also the position of stars. That they had studied the star groups is obvious from the symbolic depiction of the 7 star group of Pleiades (Pole Star)—Krittikā on a seal for the purpose of offering sacrifice at Harappa. The *Rkṣa*, as the star was known, is mentioned in the seal-inscription. The stars are nature's guide to navigators on the high seas. Further, the rising of a star known as the heliacal rising could be used for determining the annual events such as sowing and harvesting by agriculturists as the Egyptians did and for commencing sacrifices by the Indus priests. For the Greeks the rising of the Pleiades in May proclaimed that the season for harvesting the grain (grown in winter in the Mediterranean) had arrived. For Harappans too the rising of the Pleiades a millennium earlier might have been of great significance.

SACRIFICE AND INDUS CALENDAR

The excavations at Lothal and Kalibangan have revealed brick altars built for fire worship and offering sacrifices. The fire-cult was prominent and perhaps daily worship of fire was the order of the day as indicated by rectangular and semicircular altars in a house in the Lower Town of Lothal (Fig. 7). In Street No. 9 also there is a large fire altar in which terracotta cakes used as *puruḍāśa* were found in both the cities. That the terracotta cakes were used for a ritualistic purpose becomes apparent from the horned deity and a sacrificial goat depicted on a terracotta cake from Kalibangan excavation (Fig. 8). The Late Harappan site at Nageswar near Dwarka has also yielded terracotta cakes. The sacrificial altar at Lothal yielded a gold pendant of the type shown on the forehead of the statue of a priest from Mohenjo-daro. The altars of Lothal and Kalibangan contained the bones of a bovid (Fig. 9). Perhaps a sacrifice similar to the Vedic *gavāmayana* sacrifice was performed at both the cities. The *Śatapatha Brāhmaṇa* gives details of this type of sacrifice wherein the actual offering of a bull is not mentioned. Perhaps in the *Brāhmaṇa* period the offering of a bovid was given up just as the *sati* burial involving the self immolation of the wife on the death of her husband practised during the Harappan period was discarded during the Late Harappan times. There is a reference in the *Śatapatha Brāhmaṇa* to the symbolic observance of the *sati*. The *gavāmayana* sacrifice in the Vedic

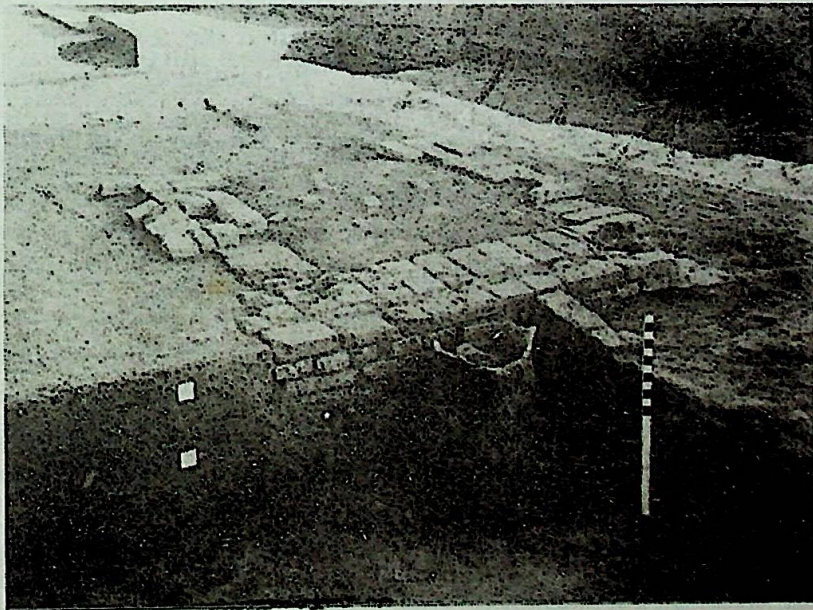


Fig. 7. Lothal: Fire altar of burnt bricks exposed in a street.



Fig. 8. Kalibangan: Terracotta cake incised with the figure of a deity on one side and a sacrificial animal led by a man on the other.

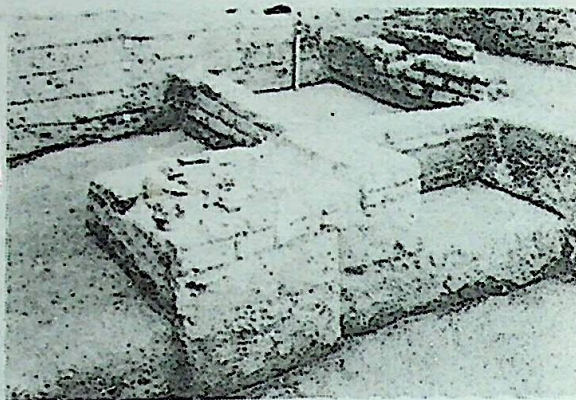


Fig. 9. Lothal: Sacrificial altar of mud bricks in which bovine bones and gold pendant were found.

period was connected with the course of the sun, which may have been true of the Harappan sacrifice also. In addition, the Harappans performed *sattras* lasting for long periods. One of the seals mentions *aśvasattra* which may be a reference to the horse sacrifice or a sacrifice to Agni, for *aśva* stood for Agni also. The Vedic *sattras* lasted for a whole year as they were symbolic of the heavenly phenomenon. The *Aitareya Brāhmaṇa* (IV. 17) says 'They hold the *gavāmayana* or the sacrificial session called the sun's gait'. The word *gavām* stands for the solar gait in the year. 'By holding the session of *gavāmayana*, they also hold the walk of the Adityas'. Some have interpreted *gavāmayana* as cow's gait. According to N. Mahadevan, the equinox occurred in the middle of the *sattra*. *Atirātra* (*Rgveda*, VII. 103.7) is the ceremonial commencement of the *gavāmayana* in the Vedic period' (S.S. Dange, 1987). The cylindrical perforated jar of the Harappan and Late Harappan times has hundreds of small holes in its walls and a large one in the bottom. N. Mahadevan suggests that it must have been used for *avabhṛta snāna* (sacred bath) when a sieve-like vessel is needed to symbolize the waters of hundreds of rivers gushing out of the holes. A sieve is used even now for pouring holy water through it over the bride and bridegroom before the marriage.

The reference in the Indus seal inscriptions to the *Magha* seems to have been the forerunner of the reference to the suspension of the cow's gait or the precession of days in *Maghas* and resumption in the *Phālgunīs*, for, the *Aitareya Brāhmaṇa* says, 'Aghāsu hanyante gāvo Arjunyo paryūhyate'. The

Harappan *gavāmāyana* might have been a symbolic way of keeping count of the days and months and adjusting the lunar calendar of 350 days to the solar calendar of 365 1/4 days.

The astronomical knowledge of the Harappans can be deducted from more than one seal. The Harappan seal no. 677 depicts a group of seven holy men representing the *saptarṣis* in the lower register. In the upper register an offering is made by a sacrificer to the horned anthropomorphic form of god Agni who is shown in a loop of *aśvattha*. The goat is standing behind the sacrificer. The inscription above reads, '*trida śāsa (sāśa) ār*' conveying the meaning 'the triply ruling and praiseworthy'. The epithet *tridhā* in the *Rgveda* is applied to Agni who is said to be in three forms namely the sun, fire and lightning or fire in water. He is depicted with three faces in the Mohenjodaro seal no. 420.

The seven *ṛsis* in the Harappan seal are symbolic of the *Kṛttikās* which is a seven-star group (Pleiades) of the *Yajurveda*. Obviously, the Pleiades must have been a seven-star group in the Harappan (pre-Yajurvedic) period also.

S.N. Sen observes,

The origin of the Indian *Nakṣatra* system has been traced to the *Rgveda* where the term *nakṣatra* has been used both in the sense of star and lunar mansions. In the former sense it appears in the *Rgveda* 1.50.2, VII.86.1 and X.68.11. In the sense of lunar mansions at least two *nakṣatras*, namely *Magha* (*Agha*) and *Phālgunī* (*Arjunī*) are referred to in the 13th verse of the Sun's bridal hymn 85 in the Xth Maṇḍala of the *Rgveda*.

Agni is the deity of *Kṛttikās* in the Vedic hymns, and *Kṛttikās* being a group of seven stars, the Harappan seal 677 depicts the commencement of the sacrifice in the *Kṛttikā* (Pleiades) *nakṣatra*. The order of the *nakṣatras* in different periods was, according to Sen, as follows:

No. in Order	Tait. Sam.	Maṭ. Sam.	Kaṭh. Sam.	Atharva Veda	Vedāṅga Jyotiṣa	Surya Siddhānta
1.	Kṛttikās	Kṛttikās	Kṛttikās	Kṛttikās	Bharaṇya	Aśvinī
2.	Rohiṇī	Rohiṇī	Rohiṇī	Rohiṇī	Kṛttikā	Bharaṇī
3.	Mṛgaśīrṣa	Mṛgaśīrṣa	Mṛgaśīrṣa (Invaka)	Mṛgaśīrṣa (Invaka)	Rohiṇī	Kṛttikā
and so on up to 28 <i>nakṣatras</i>						

Other seal inscriptions read *sapta śāsā* 'shining seven', or *sapta śāsa* 'the ruling seven'—a reference to seven star group. The inscription *sapta śāsa ṛda*

dyauh conveys the sense 'seven shining (in the) heaven or the 'seven heavenly shining (stars)'. The Soviet view that the inscription with the numeral sign for 6 followed by the fish sign refers to the six star group and stood for Krittikās is not valid because, even in the Vedic period the Krittikās were a seven-star group and hence the Harappan mention of the seven-star group refers to Krittikās.

MEASURE OF TIME

Although no time-measuring code has been found in the excavations of Indus settlements it does not imply that the Harappans did not measure time and divide the year into seasons, months, days and perhaps even hours. Fairservis refers to the markings on shell rods but it is not quite convincing. The surmises made by Soviet scholars regarding the Indus calendar may be examined here. In a paper entitled 'Mathematics and Astronomy Ancient India' read at the XVIth International Congress of the History of Science, Bucharest (1981) Dr A.I. Volodarsky has suggested that some of the Indus seals bear astronomical signs indicating dates or a period of the year. He interpreted the fish sign as *mīn* and the inscriptions containing 6 or 7 slashes followed by a fish sign were read as *āru-mīn* and *ēlu-mīn* respectively in Tamil. *Āru-mīn* is said to refer to the Krittikās (Pleiades), a constellation of 6 stars and *ēlu-mīn* to Ursa Major, a constellation of seven-stars. The *Taittirīya Samhitā* IV.4.5.1 lists the Krittikās as seven and even the names of the stars are given. In the second millennium BC the seven stars of the Krittikās (Fig. 10) were visible and the Harappans would have definitely associated the Krittikās with seven-star group. Volodarsky says that the 'horizon' sign stands for the 'sun' and 'day'. He suggests a sixty-year cycle which was unknown in India until the fourth century AD. If the Harappans had a sixty-year cycle, we will have to assume that it was forgotten in the Vedic period and again revived after two thousand years.

The association of the pole star with the Harappans referred to by Volodarsky does not make us any the wiser so far as the Indus calendar is concerned. Though it may be conceded that there was a *dhruva* (pole star) in Harappan times also, there is no means of knowing that the Harappans had recognized it or made any use of it in their astronomical system or in myths. The mere appearance of numeral signs for five on seals cannot be taken as standing for a week of five days, which was no doubt a Vedic custom. The Vedic Aryans divided the zodiac into twelve parts of 30 degrees each presided over by an Aditya, G.M. Bongard Levin and N.V. Gurov add that 'the sixty-year, or Jovian cycle adhered to in ancient India and later periods emerged in Harappan times'. This is not at all certain.

TECHNOLOGY

Chemical Practices

Beginnings of chemistry can be seen in the ceramic art of the pre-Harappans. Baking clay involved prolonged heating, fusion, evaporation and control of temperature in the kiln. Glazing and glass making, etching carnelian beads, giving an alkaline coating over steatite seals and finally smelting ores, purifying and alloying copper were well known to the Harappans.

Etching carnelian beads with beautiful designs by a special process required expert knowledge of the materials used. The white design on red background was obtained by drawing the pattern on the carnelian bead with a solution of alkali (generally soda) and then heating the stone until alkali entered into it. Another design, namely black on white, was also produced by flooding the stone with the alkali and drawing a black pattern on top of it with a solution of copper nitrate. Steatite was used extensively for making seals and beads. The seal was often coated with an alkali and heated to produce a white lustrous surface. Microbeads of steatite which are smaller than a pinhead in size are a unique contribution of the Indus Civilization. In a one gram sample as many as 310 beads were found. The quantitative chemical analysis of the bead material has shown that it is nearly 60 per cent silica, 30 per cent magnesia, 6 per cent alumina, less than 2 per cent lime and less than 1 per cent iron oxide. Initially it was thought that the Harappans deliberately mixed talc and kaolinite in the ratio of 5:1, but it was found that such a material occurred naturally with the metamorphosed ultrabasic rocks. It is known as talcose. X-ray diffraction analysis of a

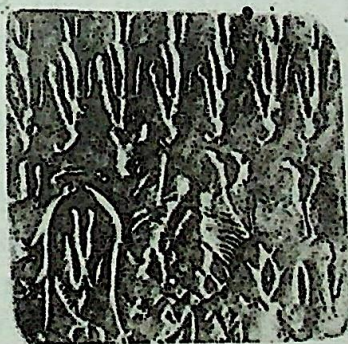


Fig. 10. Indus seal depicting the offering of sacrifice to Agni (Fire God). Seven men represent the *Saptarishis* (7 star-group)—*Krittikā*/Pleiades.

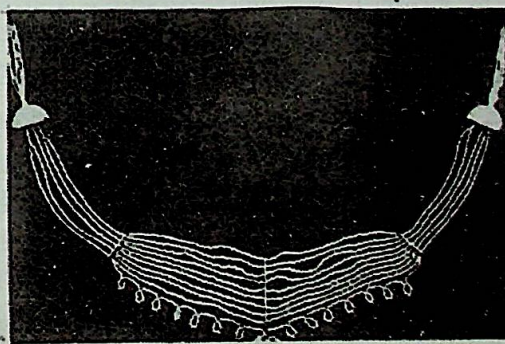


Fig. 11. Lothal: Necklace of microbeads of gold.

powdered sample of the bead also confirmed the use of talcose steatite available in the Aravalli Hills. The beads have a hardness of 6 to 7 on Moh Scale. To manufacture such beads the paste must have been rolled on a cotton string and then baked at 900 to 1000 °C in a kiln to harden the tube. Finally it was cut in small sections to produce microbeads of 1–3 mm in length and 1 mm in external diameter. Twisted bands of these microbeads make beautiful necklaces with gold beads (Fig. 11) wherein the joining of ends is hardly visible to the naked eye. Hegde thinks that since Harappans had the infrastructure for producing circular copper or bronze beads with 1 mm diameter perforations in it they could also produce copper or bronze wire of 0.5 mm diameter one end of which could be soldered or revetted. They could squeeze the talcose steatite paste through the perforations of the disc stitched to cloth and produce microbeads. The Harappan miners and smiths had good technical knowledge about metals, minerals and their physical and chemical properties. The revetted copper jars of Lothal and Mohenjo-daro indicate that the Harappans knew both soldering and revetting. They sometimes soldered the revet by pouring molten copper or bronze around its base for additional firmness. It is no wonder therefore that in later days the Dwarka smiths soldered and revetted metal parts of chariot, etc.

Pottery of the mature Harappan period is sturdy, well fired and invariably slipped red. There is also a Buff Ware. In the post-Harappan period of Rangpur and many other sites in Gujarat a distinct ware known as the Lustrous Red Ware came into use and the shapes are those gradually evolved from the Harappan pottery shapes such as the bowl, dish, and jar. Another archaeologically significant ware of Gujarat Harappan sites is the black-and-red ware which has a wide distribution in the post-Harappan period in central and western India also. A Micaceous Red Ware with distinct types such as the stud-handed bowl occurs exclusively in Gujarat Harappan sites but not in the Indus and Sarasvati valleys. Due to the presence of lime the red colour of oxidized iron did not develop and the clay burnt to buffish yellow colour. It seems that a finely levigated clay of the same composition as was used in the body but free from sand was applied (B.B. Lal, 1985). Stuart Piggot had considered the Buff Ware as a distinct culture trait when compared with the Red Ware. But at Lothal and Rangpur the same people produced both the wares and the colour difference was due to the composition of the clay. The black-and-red ware was produced partly under oxidizing and partly under reducing conditions. On the contrary, the Lustrous Red Ware which has a generic affinity with the Harappan Red Ware, can be taken as the culture trait of a newly-evolved culture. The surface of the vessel is rendered smooth by burnishing and given a slip of finely-

levigated red ochre. It is also probable that in its green state the pot was subjected to burnishing with pebbles of hematite such as those found in Rangpur excavation, which left a fine powder of iron oxide securely adhering to the surface. The pot was then fired in an oxidizing atmosphere. The decoration in red was evidently post-firing (B.B. Lal, 1985).

Metals and Metallurgy

The Harappans made plentiful use of precious and base metals in agriculture, industry and trade and for personal ornaments. Gold was used for making beads, pendants, armlets, broaches and ear studs. The Indus gold, especially that of Mohenjo-daro and Lothal, is light in colour indicating a high silver content. Being unrefined electrum, it seems to have come from the Kolar reefs and Hatti. The Neolithic and Neolithic-chalcolithic settlements such as Banahalli and Kendatti in Kolar district as well as Maski and Piklihal in Raichur district, Sanganakallu in Bellary district of Karnataka, Ramavaram and Patapadu in Kurnool district of Andhra Pradesh had trade contacts with Harappan and Late Harappan settlements in Gujarat and the Indus valley through Daimabad and Lothal. They exchanged semi-precious stones, gold, chert and steatite for copper and copper tools and steatite beads. The south Indian gold mines were one of the major sources of supply to the Indus cities. Another source seems to have been Afghanistan. The Harappan trading post of Shortugai is situated in the same region in which the Fullol Hoard in the Hindu Kush of northern Afghanistan was discovered. The hoard has several gold objects with Mesopotamian and South Turkmenian motifs. Turkmenia itself has a couple of Harappan sites, especially, Altin Depe where a Harappan seal and ivory objects are found. The Harappans supplied ivory to Central Asia through Shortugai and got gold in return.

It is not unlikely that the Zawar mines near Udaipur supplied a small quantity of silver needed by the Harappans. Though Kolar and Anantpur gold mines yield silver it is doubtful if they were an important source. An alternate and more likely source is Afghanistan, especially Hazara Jat, Faranj and Panjsher valley in southern Hindu Kush.

Lead was added to copper to increase the feasibility of molding. Its occurrence in a number of copper objects from Harappan sites shows it was available in plenty. The discovery of copper together with a small piece of lead in a bricklined pit in a house at Mohenjo-daro is taken to suggest the use of lead mainly as a smelting flux. Balakot in Makran (Pakistan) has yielded a flat semicircular piece of native lead. Afghanistan and Iran and Kazakhstan are said to be the main sources of lead for the Harappans. The

seven Harappan settlements at Shortugai at the confluence of the Oxus and the Kokcha in the Hindu Kush suggest that the Harappans established trading posts here to monopolize trade in raw materials from northeast Iran and Soviet Central Asia. The main sources of copper are the Khetri-Ganeshwar mines in Rajasthan. It is doubtful if the Bihar mines were exploited in the third millennium BC, and even if exploited they are situated far away from the Harappan trading centres. The Agnigundala mines in Andhra, where there is ample evidence of working and smelting copper and also the Kalyadi and Chitradurga copper mines in Karnataka were worked in the first few centuries of the Christian era and later too. The Kalyadi and Chitradurga mines seem to have earlier workings as attested to by their megalithic association. Copper deposits in Zhob district, Robat and Shah Bellaul in Baluchistan are other sources for the northwestern region. Iran with its rich source of copper and long history of metallurgy might have been another source, more so during the Late Harappan Period when Luristan bronze technology of casting figures and producing superior weapons was developed and influenced other countries on the east. Even Oman must have supplied copper to the Gujarat Harappans. Bahrain was an important station on the trade route of the Harappans who had established trading centres and colonies in southern Mesopotamia, Failaka island, Oman and Bahrain.

As tin was difficult to obtain, the Harappans had to use it very sparingly. Lothal smiths meticulously avoided the use of arsenic containing copper. On the other hand it is observed that the Late Harappans of Daimabad and the copperhoard people of the Gangetic valley used arsenic for hardening copper objects.

Large quantities of copper oxide ore from a bricklined pit in the DK Area of Mohenjo-daro and the two mud-lined pits of wedge-shaped bricks which are vitrified suggest use of these pits as furnaces. The ore used was copper oxide. According to D.P. Agrawal, 8 per cent of tools from Mohenjo-daro indicate arsenic alloying in the range of 1-7 per cent. Nickel was deliberately used with copper in Rangpur where three artifacts show nickel in the range of 1.8 to 5.8 per cent. The presence of a high proportion of tin which is as much as 11.20 per cent in the case of a bangle, 13.80 per cent in the case of a pin and 9.62 per cent in a chisel cannot be treated as accidental. It was used for producing a harder metal than copper. Bronze-making and metal working had reached a fairly high degree of technical excellence at Lothal.

Daimabad, a Late Harappan settlement on the banks of the Pravara, a tributary of Godavari in Ahmednagar district of Maharashtra has yielded a unique hoard of four bronzes cast solid (Fig. 12). Nagpal, Director

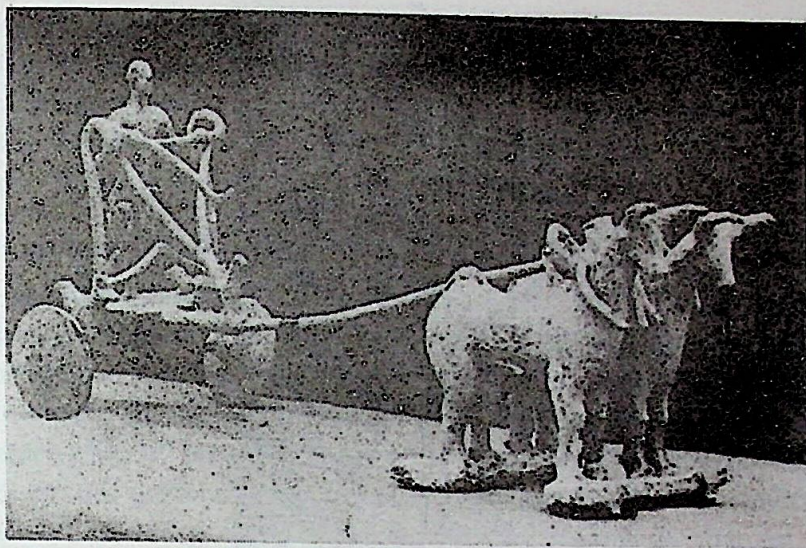


Fig. 12. Daimabad: Charioteer holding a whip in a chariot drawn by bullocks. A dog-like animal is also seen.

(Science), Archaeological Survey of India who carried out chemical analysis of the objects reports:

While the two parts of the rhino showed varying proportion of tin, viz. 9.85 per cent and 6.51 per cent, the bulls of the chariot showed differences in tin content, namely, 5.36 per cent and 4.58 per cent in different portions of the body. The chariot wheel contained 5.03 per cent tin. As these images are made of low tin bronze the melting point of the alloy must have been somewhere between 1083 °C and 800 °C. Obviously furnace technology was fairly well developed to attain a high temperature.

It may be noted that the furnaces were found on the river bank at Daimabad in the Malwa level (1600 BC) in Sector I. One of them has two flues. One flue was used as a stoke hole and the other is connected with a large thick-walled pot ensuring thereby the easy flow of molten metal. Fragments of thick pottery vessels coated with clay and lime used for constructing the walls of the furnace are also recovered. Dumps of slag, lime and charcoal are seen at several places. Daimabad must have been an important copper-bronze working centre as indicated by the occurrence of bronze images and copper tools. The Harappan technique of casting metal objects (Fig. 13) had made further progress here. It is therefore a clear case of Late Harappans improving their skill in metallurgy. Bun-shaped ingots of Lothal and Mohenjo-daro suggest that the pit in which the molten metal was run had a concave undersurface and the lug indicates the running of the metal through a narrow channel before entering the pit. Some smelts broken up



Fig. 13. Mohenjo-daro: Dancing girl (bronze).

from the ingots are also found. They are remelted in the type of furnace found at Lothal as indicated by the terracotta crucible found here. Channeled crucibles with thick walls of clay mixed with sand were used for casting long bars which were subsequently hammered into chisels, rods, etc. Such crucibles have been recovered from the coppersmith's workshop in the Bazaar Street of Lothal, where a rectangular kiln of bricks and a stone anvil are *in situ*. In another workshop cast bars were further worked into tools. A stone mould used for casting pins and awls is also found.

Forging and fabricating were well known to the Harappan smiths. The metallographic analysis of Harappan copper/bronze tools shows that by cold hammering the hardness of the artefact was increased from 87 to 135 B.H. Nos. They resorted to annealing (reheating) to make the metal malleable and ductile. In the manufacture of a large variety of copper vessels the smiths used *sinking* and *raising* to beat the metal disc and shape it into the required form. Mackay thinks that spinning and turning were also used. The casting of the figure of dancing girl from Mohenjo-daro must have been done in *cire perdue* technique. Welding was not known but lapping was known to the Harappan smiths. The tubular drill was used for boring holes in steatite seals and buttons and also in harder materials like chert and agate. The more advanced machine technology of the third millennium BC is indicated by the Lothal drill (Fig. 14) with twisted grooves. The angle of the flute

and the speed at which the drill moves determine the material holed. Wood and low tin-bronze and copper were drilled with the aid of this tool. The incurved saw of bronze from Lothal, used for making grooves in metal rod or shell objects, is the forerunner of a circular toothed disc of iron or steel referred to as *cakra* in the *Mahābhārata*.

Post-Harappan Metallurgical Processes

Underwater archaeological excavations (1986–92) off Dwarka by the Marine Archaeology Centre of the National Institute of Oceanography under author's direction have yielded a number of copper, bronze and brass objects. What is interesting is while the copper *lota* is corroded the brass parts of a miniature chariot buried in sediment in 5 to 7 m water depth are not corroded. Even if the brass objects are of period B, say 1500 to 2000 years old in Dwarka, at the present rate of corrosion the brass objects must have disappeared. What was the secret of alloying copper in the post-Harappan and Early Historical Periods, to reduce the corrosion rate? Recently Mr C.S.R. Prabhu, the Technical Director at the National Institute of Information, Hyderabad, examined the brass objects of Dwarka and was not surprised that they were not corroded even after 1500 years or more in the sea because the ancient *pancha loha* a copper alloy with lead and zinc was not only highly malleable, that is capable of being worked with machine, but was also resistant to salt water corrosion. Till now this property was never seen in copper alloys. *Āra Tāmra*, another salt-water resistant copper, turned out to be brittle but very light. (*Indian Express*, Bombay, December 5, 1992). Mr Prabhu in his lecture at the Indian Ceramic Society Bangalore.



Fig. 14. Bronze drill bits (twisted/hollow) from Lothal.

observed that *Chapala grahaka* turned out to be an exquisitely fine porcelain and cored differently, a very soft glass which was very resistant to all acids and alkalis. He is working on 14 more materials mentioned in six manuscripts with Pandit Subbaraya Sastry of Anekal who had copied ancient manuscripts. Among them 'The Syntax indicated that the text dated from a post-Vedic but pre-Mahabharata era and is said to refer to the construction of "Vimānas". Sadly, the six manuscripts covered only part of the construction process, thousands of other "shastras" which would have given the full process have been lost.' Mr Prabhu, after deciphering the texts duplicated the alloys as described in them. 'All of them had demonstrated the unique properties in laboratories here and abroad. For instance, tests in San Jose, California confirmed that *Tamogarbha loha* a lead alloy, was capable of absorbing an astonishing 85 per cent of light generated from a ruby laser'. The texts also described mine contours at various locations and indicated what kind of ore could be found at different levels. Methods of extraction and purification were also described in detail. The texts, some of which were written by the Maharshis Bhāradwāja and Yājñavalkya indicated the high technological knowledge attained by the ancients of India which had somehow been lost over the centuries.

AGRICULTURE

The urban centres of the Indus Civilization depended on the rural areas for a regular supply of food grains. The domestication of wild varieties of rice, wheat and barley and also the cotton plant had taken place in the 6th millennium BC. At Mehargarh, in Kachi District of Baluchistan, excavations by Jean-Francois Jarriage in the fifth millennium BC occupation level have brought to light food grains, a large granary and the agricultural implements used by them. The charred grains identified include cotton seeds and several kinds of wheat, for instance, *Triticum aestivum-compactum* and barley. In the Neolithic settlement (5000 BC) of Mehargarh the diversification in agriculture is suggested by the impressions of two-row hulled barley (*Hordeum distichum*), six-row barley (*H. vulgare* and *H. vulgare van nudum*) and bread wheat (*T. durum/aestivum*). The sickle and grinding stones found along with cereal impressions in lumps of clay suggest that agriculture had made good progress.

The settlement of Period III (early fourth millennium BC) of Mehargarh is considered a phase of technological innovation and diversification of agriculture, accounting for the earliest appearance of oats (*Avena sp.*) and the addition of *Triticum sphaerococcum* to the group of wheats.

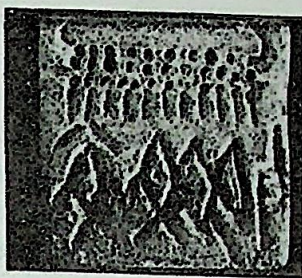


Fig. 15. Seed drill engraved on a terracotta seal from Lothal.

The Harappans used bread wheat, barley, peas or the field pea (*Pisum arvensis*) and rai, a species of *Brassica* and bajra, the last item being confined to Saurashtra. Impressions of rice found in Rangpur and Lothal confirm that rice was also used in Gujarat. The earliest rice in India comes from Koldihwa-Mahagara area (fifth millennium BC) in the hilly tracts of the Vindhyan foothills in the Belan valley. Domestication and cultivation of rice is noticed in the Neolithic settlements of this region. But there is no evidence of use of rice in any Harappan site except Lothal and Rangpur.

Among agricultural implements the copper sickle and wooden plough were in use. Miniature terracotta models of a plough are found in Banawali. The most interesting agricultural implement depicted on a seal from Lothal is the seed-drill (Fig. 15) of multiple furrows. This type of seed drill-curr-plough was in use in Egypt and can be seen even today in some remote parts of Karnataka.

In brief, it can be said that there was variability in crops grown in various parts of the vast empire. A rotation of crops in Kalibangan is suggested by B.B. Lal in his discussion of the ploughed field of pre-Harappan times.

Another interesting fact that has come to notice at Lothal and Kalibangan is the collection of gypsum and its storing. Perhaps it was used as a fertilizer for reclaiming saline lands. In Saurashtra the Harappan sites were being affected by high salinity of the soil. Here is an instance of the knowledge of chemical fertilizer possessed by the Harappan farmer.

BOTANY

The presence of teak (*Tectona grandis*) in Phase II of Lothal is highly significant. There is at present no teak at all in any part of the Saurashtra region of Gujarat except in the Gir area where the rainfall may be as high

as 120 cm or more. In the north the teak-growing areas of Sabarkantha and Banaskantha and in the south Surat fall under tropical dry deciduous teak forests which may often merge into the thorn forests. The occurrence of *Tectona grandis* and *Adina cordifolia* along with *Acacia* and *Albizzia* suggests that both the forest vegetation and the climate in the Lothal region in 2300 BC may have been different from the present. The forests probably were of the tropical dry (mixed) deciduous type somewhat similar to those occurring in the Gir area and Panch Mahals, indicating a somewhat wetter climate with higher rainfall. The presence of a Lauraceous wood (of which a highly calcined wooden beam was found at Lothal) also tends to confirm this. The absence of teak in phase III (2000 BC) and the occurrence of only *Acacias* in Phase IV (1900 BC) show that at some time or the other the wetter conditions may have been followed by a period of drought and progressive dessication leading to changes culminating in the tropical thorn and desert scrub vegetation of today. 'The drought in AD 1900 in Godhara range killed 90 per cent of teak while babul (*Acacia arabica*), hewar (*Acacia leucophloes*), siri (*Albizzia lebbek*) and rohini (*Soyimida febrifuga*) were least affected. Similar causes may be presumed to have existed around 2000–1900 BC in Saurashtra. In Period A (Phase I-IV) of Lothal (2400–1900 BC) there was flourishing overseas trade and ship-building must have been an important industry, as indicated by the terracotta ship models and wood specimens found here (Ramesh Rao *et al.*, 1985). Deforestation led to soil erosion, silting of river mouths and sheet flooding of Harappan towns.

TOWN PLANNING AND PUBLIC HYGIENE

In pre-Harappan Kalibangan and Mehragarh there is a semblance of orderliness in the formation of a road flanked by houses, but there was no overall planning according to a blue print dividing the town into various sectors in an orderly way and providing civic amenities and ensuring that municipal regulations were strictly followed. All the important commercial and industrial towns of Harappa, Mohenjo-daro, Lothal, Kalibangan, Dhola Vira, and smaller towns such as Surkotada and Banawali were planned on the same lines. The dichotomy of Harappan towns and cities which separate the Lower Town from the Acropolis or citadel is unmistakable everywhere. The purpose was to provide an impressive mansion to the ruler as distinct from the less impressive houses of the ruled. In most towns and cities the primary consideration in building a peripheral wall of mud-bricks or stone depending on the material available, was to protect them against inundation by the overflowing rivers or against tidal waves. As an additional precaution, the ruler's mansion and public buildings including the warehouse, granary and

a few religious structures like the one at Kalibangan were built on 3 to 4 m high platforms of mudbricks to prevent damage by floods. The houses in the Lower Town were also safeguarded against floods by constructing massive platforms which served as a common plinth for groups of dwellings. Where the scouring action of water was heavy the peripheral wall and even the outer face of platforms in the Lower Town were given burnt-brick revetments. These antiflood devices were mistaken by early excavators for defences against the invading enemy forces.

In general, the Harappan towns were divided into several blocks, each consisting of 20-30 houses standing on a common artificial platform of mudbricks and mud. The granary was situated in the citadel or outside. In Lothal the warehouse, where goods were cleared and sealed for export and the imported ones were examined, is situated in the Acropolis mound. The industrial sector was segregated from the residential sector, for instance, the bead factory and smithy were located in separate sectors away from the bazaar at Lothal (Fig. 16). The granaries of Harappa and Mohenjo-daro and the warehouse of Lothal were provided with intersecting passages and

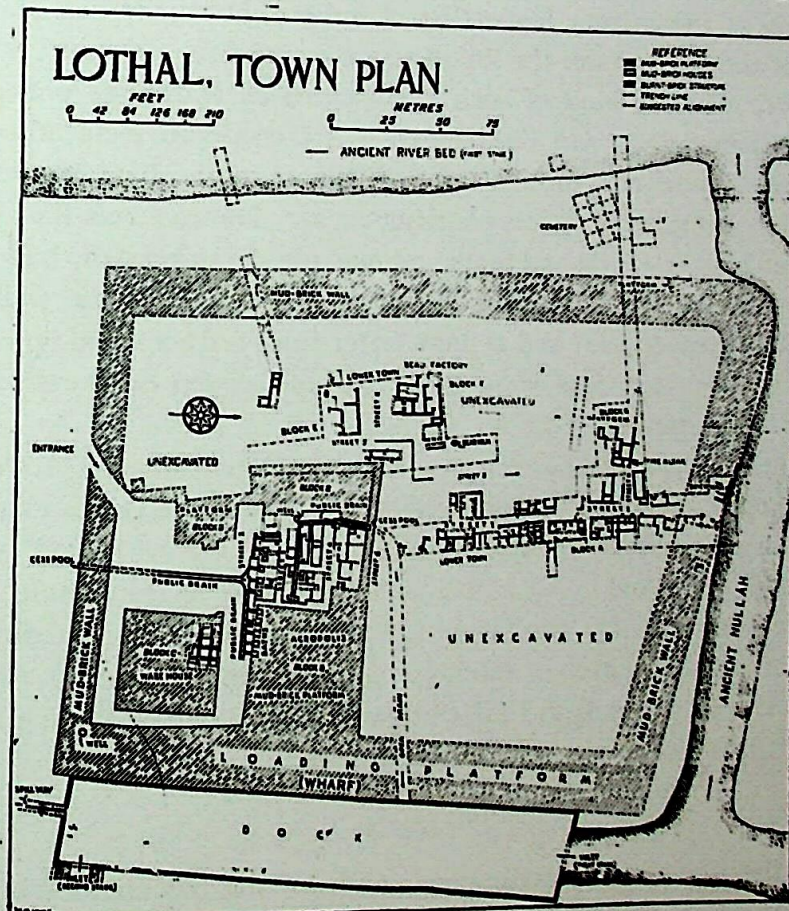


Fig. 16. Lothal: Town Plan

air-ducts so as to ensure that perishable goods were not spoilt. Big cities like Mohenjo-daro had large assembly halls or the so-called college of priests. The Great Bath of Mohenjo-daro is a unique structure with adequate number of cloak rooms and provision for supply of fresh water to the bath which could be cleaned periodically. The planning of the town of Dhola Vira (Kotada) shows fortifications and division of the town into three main sectors, according to Bisht. The streets ran in the cardinal directions in Lothal and Mohenjo-daro. They were broad enough for two-way vehicular traffic. The lower city in Harappa and Mohenjo-daro was divided into blocks of 240 × 360 m. Twelve such blocks in three rows of four are laid bare in Mohenjo-daro. The western block was the citadel. An important feature of Harappan planning is the great care taken to keep the cities, towns and villages clean by providing underground and surface sewers, manholes and cesspools. Each house was provided with an inspection chamber at the junction of the private drain and the paved bath to remove solid waste and allow only liquid waste to enter the public sewer. At the mouth of the main drain there was a wooden mesh to hold back the solid waste that might have escaped detection at the private inspection chambers. From the cesspool at the mouth of the main sewer the liquid waste entered the dock at Lothal. It is no wonder that the land of such clean cities as Harappa, Mohenjo-daro, Lothal, Chanhu-daro and Kalibangan was considered a paradise by the Sumerians whose clay tablets refer to Dilmun as the land of clean cities where the Sun rises first and elephants roam. The roof was flat, made up of wooden beams, reeds and mats and mud plaster to keep the building cool in summer and warm in winter. Pottery pipes built into the walls of the groundfloor carried rain and sullage water from terraces and upper floors. Privies and soakage jars were built into the ground on the principle of modern septic tanks.

Recently the German delegation of the Department of Architectural History in the Technical University of Aschen has started rechecking all the architectural remains of Mohenjo-daro. Its preliminary report says that several units in Blocks, AB and E in Moneer Site share certain common features. They have (1) similar grid plan, (2) similar exterior dimensions (150 sq. m approximately in extent) and proportions (0.8 to 0.9), (3) similar interior access systems and (4) compartments in corresponding locations in these units having similar dimensions and proportions.

DOCK

One of the important contributions made to marine engineering by the Harappan engineers is the construction of a tidal dock at the most conve-

nient site. They provided other facilities such as wharf for handling cargo and warehouse to store and inspect incoming and outgoing cargo. Quarters were also provided for dock-workers. The selection of the site itself shows that the planners had learnt by experience that the dock for berthing ships should be located away from the main stream to avoid siltation during floods. Of all the other estuaries the Sabarmati estuary was found most useful because the tidal amplitude is the highest (10 m) here, and large ships could easily sail up the river Bhogavo which anciently washed the western edge of the town. N.K. Panikkar, former Director of the National Institute of Oceanography who studied the dock says that 'this is the earliest evidence in the world of putting to practical use one's knowledge of tides, current and waves for sluicing ships at high tide into the basin. This is the largest structure built by the Harappans in their empire and its role in the economy of the empire can be judged from the fact that ships of different countries must have visited Lothal as evidenced from the occurrence of a Bahrain seal, a terracotta model of a Sumerian captain or merchant, models of Egyptian mummy and gorilla besides imported Mesopotamian pottery' (N.K. Panikkar, *et al.*, 1971). The Lothal dock, 211 × 35 m, with a brickwalled basin having a 13 m wide inlet in the northern embankment could accommodate about 30 ships of 60 to 75 tons of laden weight (Fig. 17). The ships entered the basin at high tide in a 4 m column of water and the spill channel constructed just opposite the inlet not only discharged excess water but also ensured automatic desiltation of the basin. At low water the spill channel was closed by lowering a wooden door to retain a 1 m draught for float-

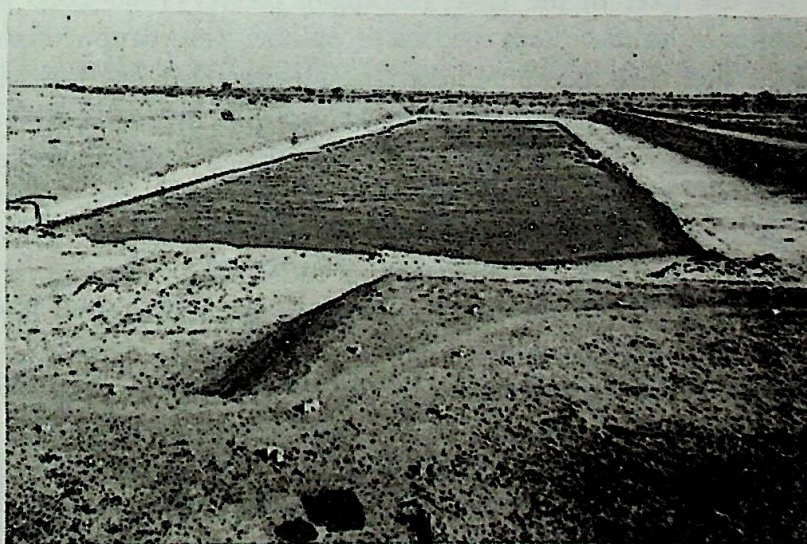


Fig. 17. Lothal: Tidal dock with outlet (spill way) in the foreground.

tion of ships. The offsets on the outer face of the walls took care of water thrust, while the inner vertical face enabled the boats to touch the edge of the wall for hauling cargo.

The wharf is 240 m long and the warehouse built close to the dock and measuring 50 × 40 m, had as many as 64 platforms with a network of airducts for stacking goods which were kept well packed and sealed. An accidental fire destroyed the goods, but the burnt clay sealings bearing impressions of packing material confirm the commercial use of Indus seals. The Lothal warehouse is twice as large as the Mohenjo-daro granary indicating that a large volume of overseas trade was handled by the Lothal port in 2000 BC.

COMMUNICATION OF THOUGHT

The greatest contribution of the Harappans to human progress is the invention of an alphabetic system of writing by simplifying a partly pictographic script by dropping pictures and using simple cursive signs with basic phonetic values (S.R. Rao, 1982, 1987 and S.H. Ritti, 1985). The hieratic writing of the early phase (2500–1900 BC) consists of pictorial signs such as pipal leaf, scorpion, hill, human hand, insects, compartmented or ploughed field and birds drawn by the side of cursive signs some of which simulate Roman characters such as D, E, H, P, U, V, W, X, Y, etc. The accenting and joining of the cursive signs produced pseudo-pictures of 'warrior', 'carrier of load', 'archer with two bows and arrows', 'wielder of two shields', 'trident carrier' and the like. In the Late Harappan phase (1900–1600 BC) the pictorial signs of animate and inanimate objects were dropped and only cursive signs and their combinations (pseudo-pictures) were retained. A careful analysis of the pseudo-pictures shows that the number of basic cursive signs was 22 in the Late Harappan phase, while in the mature Harappan phase the basic signs (including 28 pictorials) were 62. With so few basic signs the Indus writing could only be phonetic, but not pictographic or ideographic. The technique of attaching diacritics or strokes to consonantal signs for indicating the medial vowel, as in Brahmi, and the ingenious method of joining two or more basic signs to form *samyukta akṣarās* (conjunct consonants) give a distinct character to the Indus script and other evolved writings of India. A majority of the Late Harappan cursive signs are identical with a majority of the Semitic alphabets. Both are almost contemporary. The phonetic value of the signs in the deciphered Semitic script is given to identical Late Harappan signs. The credit for disciplining a partly pictorial script into a simple alphabetic writing, without which quick recording and

easy communication of ideas is not possible, must go to the Harappans. This contribution of the Harappans made sophistication possible. The decoded Indus script (Fig. 18–22) confirms that the language of the Indus seals and tablets is found to belong to the Indo-European family showing close relations to the Old Indo-Aryan (Vedic) at an age when it had not yet snapped all links with the Old Iranian of the *Avesta*. A few examples of the Harappan technique of writing in simplified form and the method of decoding the script are given in Figs. 18 to 23. The use of words *aeka*, *happt*, *daśa*, *śata*, etc., for cardinals one, seven, ten and hundred respectively confirms the above hypothesis. Secondly, the names of rulers and ṛṣis, such as Atri, Kasapa, and Manu and of sacrifices and commodities, e.g., *aśvasatra* and *trapu* also occur in the seals. After ascertaining the language of cursive writing as Old Indo-Aryan, syllabic values are given to pictures of the early Indus script which had a phonetic connotation (S.R. Rao, 1991). Thus the early Indus seals were also read.

The principle of proceeding from the simple to the complex and from the known to the unknown is followed in decoding the Indus script.

YOGA

The credit for developing the science of *yoga* should go to the Harappans. The terracotta figures of Harappa and the deities on the Indus seals are shown in yogic *āsanas*. *Yoga* is an intuitive science which deals with the ranges of physical and spiritual being and discovers greater secrets of physical and psychophysical and other higher worlds. It ensures discipline in all walks of life. The spirit of disciplining man extended to disciplining the partly-pictorial and partly-phonetic writing into a simplified cursive alphabetic writing from which the Semitic and Brahmi scripts have developed.

The religion of the Harappans, as indicated by the fire and sacrificial altars found in the excavations at Lothal and Kalibangan was not much different from that of the Vedic people. What is significant is that the Harappans succeeded in bringing about a cultural integration of the fire-worshipping and animal-worshipping groups as attested by the composite animal deities engraved on seals.

The conceptual thinking of the Harappans about the Fire God as having three forms is suggested by the tricephalic god on the so-called Paśupati seal. In other seals he is called *Bhag Arka*. He is said to be *tridha*, that is, in three forms, a concept reminiscent of the R̥gvedic Agni as fire, sun and lightning or fire in water. The fire altars of Lothal and Kalibangan are of two types, one similar to the Vedic and the other to the Iranian altars. The

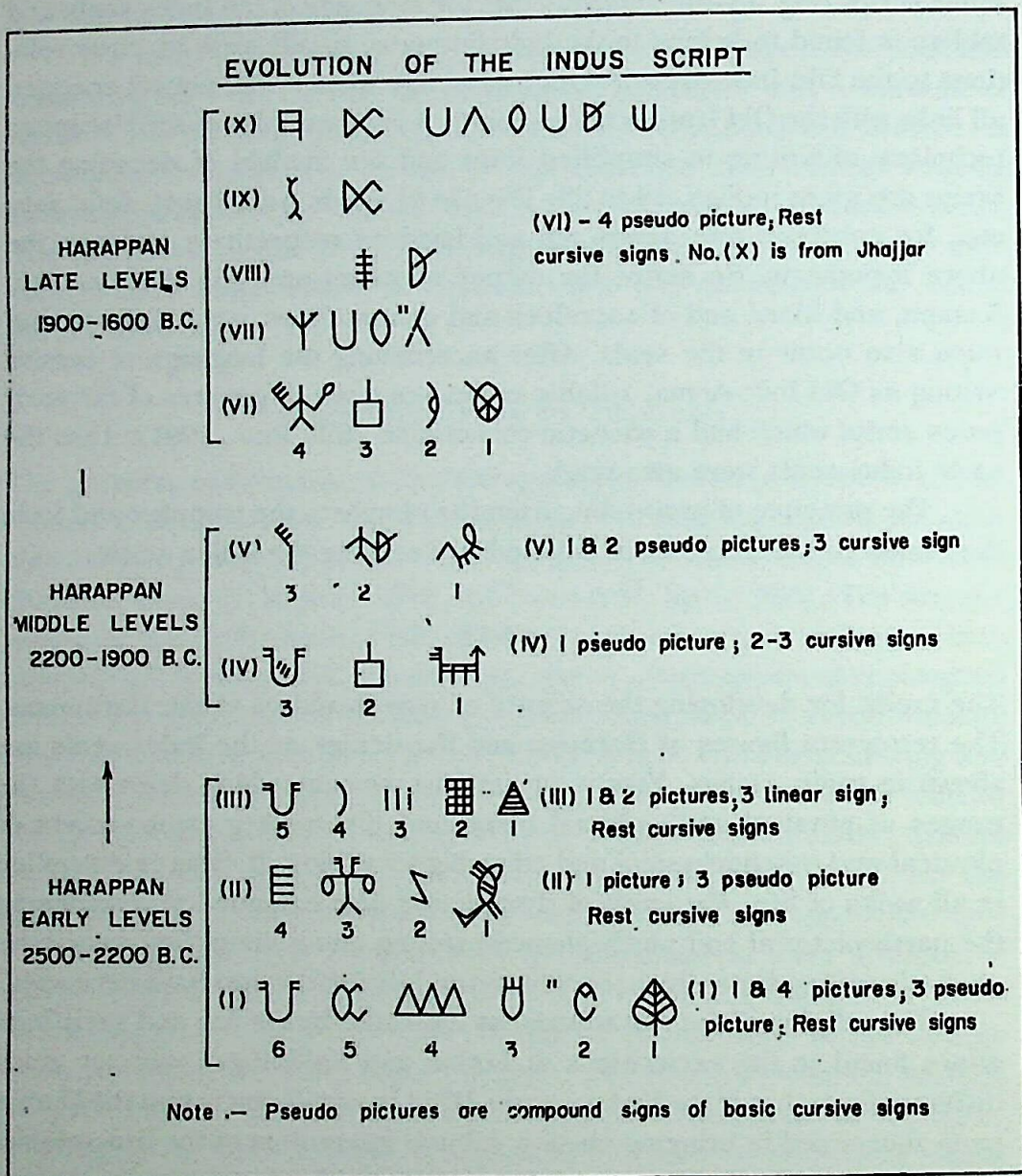


Fig. 18-22. Evolution and decoding of the Indus script.

S No	Seal No	Inscription with Basic Sign	Basic Sign	Accented form of Basic Sign	Inscription with Accented form	Seal No.
1	M. 476	◊ U U	U	U	U ◊ ✕	L. 62
				UF	UF ✕	
				UF	UF) U Y ◊	
				UF	UF	
2	L. 70	△ UF ◊ :::: U Δ V	↓	Y	Y III " ◊	MK. 180
3	MK. 601	7 ↑	7	7	U UF 7) ◊	L. 94
4	V. 224	UF X Λ	Λ	Λ	U Λ ◊ U Λ	L. 138
5	MK 666	UF Λ " ◊	Λ	Λ	do	do
6	M. 179	UF ↑ X	X	X	X ✕ ✕	V. Pl. C1. 8
7	MK-148	E D △	D	D	D U	V. 231
			D	D	see	L. 138 above
			△	△	△ U E	M. 225
				△	E △ U	M. 46
				△	U U U	M. 206
8	M. 370	UF X S ✕	S	X	X ✕	L. 113
	MK. 200	UF 2 P	2	P	UF 2 P	MK. 200
9	V. 114	Y III UF) P.	)	), P, P	UF P	M. 272
10	V. 99	UF Y ◊ O	O	①	UF ①	M. 236
				①	E D ①	V. 423
				①	D ①	V. 455
11	L. 665	UF U ◊ " ◊	◊	◊	U ◊ △	V. 267
				◊	E D ◊	V. 662
12	L. 19	UF □ (1)	□	□	Y ◊	L. 141
				□	U ◊	4823
13	MK. 183	UF U, X UF X UF	X	X	UF X	L. 136
				X	U X X	

Fig. 19

	1900-1500 B.C. LATE HARAPPAN SIGNS (BASIC)	1500-1000 B.C. NORTH SEMITIC & SOUTH SEMITIC SIGNS	PHONETIC VALUE	1300-B.C. BET DWK	1300-800 B.C. MEGALITHIC SANUR ETC.	3rd CENT BC ASOKAN BRAHMI GIRNAR
1			b			ba
2			g			ga
3			d			dha
4			h			ha
5			w			va
6			h			
7			th			tha
8			k			ka
9			n			na
10			s			sa
11			(ay)			
12			p			pa
13			r			ra
14			s			sa
15			t			ta
16			s'			sa
17			h			gha
18			m			ma
19			a			a
20			r			
21			s'			
22						ca
23			z			
24			y			ya

Fig. 21

Sl. No.	INSCRIPTION	TRANSCRIPTION	MEANING	SEAL No.
1		<u>pag</u> , <u>paga</u>	strength or strong	V 129 (U)
2		<u>pag-da-</u> or <u>bag-da</u>	bestow strength or god bestower	K 201 KG 209 MK 371 V 129
3		<u>pak.</u> <u>pa-ka</u>	pure (<u>pāk</u>) or guardian	MK 269 MK 934
4		<u>ppa-ka-hā</u> or <u>papa-ka-hā</u>	(seal) of guardian or (seal) of protector ka (prajāpati)	MK 139
5		<u>pak-ppat</u>	pure (or guardian) master (or rule)	M 45
6		<u>sa-ha-pāt</u> <u>saha</u>	almighty, protector or governor	MK 530 V 222
7		<u>ba-ka-pāt</u>	Baka protector or governor	MK 5
8		<u>ba-da</u> = <u>bada</u>	firm	MK 638
9		<u>vah-pah-hā-hā</u>	(seal) of protector of protector	M 204
10		<u>pā-da-h</u> = <u>pādah</u> / <u>pā-dha</u>	of foot/protector bestower	V 421-23, V 610 V 682
11		<u>dā-sa</u> = <u>dasa</u>	n of a person or author of a Sāman	RG
12		<u>ga-rā</u> = <u>gara</u>	or a drink	
13		<u>phah -rā</u>	protect bestow, or bestower of protection	MK 206
14		<u>gā-rā</u> <u>hā-hā</u>	Gara brilliant	MK 347
15		<u>ppak</u> - <u>rā</u>	guardian (or pure) bestower	MK

Fig. 23

concept of 'order' is prominent in the cosmological thought of the Harappans who use the term *ṛta* and *asa*. These terms were used by the Vedic seers. The Avestan term for order is *asa*. Both the Harappan thinkers and Vedic seers call Agni (*Arka*) as *ekapāt*, the single protector (source of energy).

The discovery of the great port-city of Dwarka on Gujarat coast has contradicted the general assumption of descent of a dark age on India after the Indus cities declined. The continued use of Sanskrit language in Late Harappan script gradually evolved into Brahmi script, the use of seals, the construction of port structures and introduction of iron technology by 1500 BC. bear testimony to the progress of civilization in India during and after the Vedic Age (Rao S.R., 1992, 1993).

Modern physicists like Bohm view quantum mechanics as providing an indication that there is unobserved order in nature. B.D. Josephson says

if what Bohm is doing with unmanifest order can be combined with the mathematics of intelligence, we will be well on the way to integrating God and his domain into the framework of science. It is a correlation between the details of physics and the details of reality revealed by e.g., the meditative experience. The ordinary reality as perceived by the senses corresponds to classical physics. The subtler realities of the astral or celestial worlds correspond to the aspect of physical reality described to transcendental experience. These three experiential realities are experienced successively as one goes deeper into meditation.

It is this kind of meditation which the Harappans seem to have practiced and conceived of order, cosmic and moral. In brief, the unshakeable foundation of the Indian civilization and scientific thought was laid by the Harappans.

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Scientific Tradition and Other Traditions

B. M. UDGAONKAR

Introduction

In the Project of History of Indian Science, Philosophy and Culture, our concern has to be with the trio—Science, Philosophy and Culture—in interaction with one another. This is where the uniqueness of the Project would lie. Uni-dimensional discussions of any one of the trio should have no place in the volumes that result, except where they raise important questions at the interface(s). And in that case, experts in the two (or three) dimensions should have sessions together to sharpen the questions, and to the extent possible, arrive at (even tentative) answers to these. This has already been emphasized by Prof. D.P. Chattopadhyaya.¹ However, it bears repetition in view of the contents and presentation in some of the Occasional Papers that have been brought out so far.

Indian civilization is about 4,500–5,000 years old (including the Indus Valley Civilization period; 8,000 years old, if one includes the pre-Harappan findings in Baluchistan also). During this period, India has made many important contributions to science, technology, philosophy, and culture. How did the developments in each of these areas influence one another? During this long period, what was the place of science in philosophy and in the civilization at large, at different epochs?

What role do the dominant scientific concepts play in the differential development of philosophy in different cultures? For example, B.N. Seal² observes that 'Hindu philosophy on its empirical side was dominated by concepts derived from physiology and philology, just as Greek philosophy was similarly dominated by geometrical concepts and methods', and adds: 'Comparative philosophy, then, in its criticism and estimate of Hindu thought,

must take note of the empirical basis on which the speculative superstructure was based'. This assertion would merit a detailed discussion. Is it true? or an over-simplification with regard to both Greek and Hindu philosophy?

Established science at a given time influences philosophy and *vice versa*, though radically new developments do so usually with some time lag. How does one see these influences at work, in general in the Indian context? What were the positive and negative influences at different epochs? Chronology becomes important in this context. There are, however, serious chronological uncertainties in Indian history.

In the case of science, one tends to compare the Indian situation with the developments in Europe over the last few hundred years, gets overawed, and it is not uncommon to hear loaded counterfactual questions like 'Why did India have no science? Is it because of its tradition?' In asking such questions, the foreigner, and following him, many Indians, forget that science based on observation and empirical methods is to be found in the practice of the ancients in India, and that science is as much a part of our heritage as the greatly extolled mystical tradition.^{3,4,5} One has legitimately to take a longer time scale for any comparison, and counter the ethnocentric prejudices with facts.

The time-scale of several thousand years also means that concepts may have changed with time. This has to be constantly kept in view. For the impact of any given concept, e.g. *Māyā*, one has to ask what was the meaning attached to it during different epochs.

Indian contributions to science and technology, from the earliest times, have begun to be documented,^{3,4,5} though there is no comprehensive work yet comparable to that of Needham and co-workers on China. It is, however, by now recognized that India's contributions to science and technology over the centuries are quite significant. This is, however, not the subject of our discussion. Rather, we will try to survey the reasons which have been often adduced as to why, in spite of a strong early base in science and technology, India failed to build on it during the last five hundred years. Why did this happen?

Why did India Lag Behind in Recent Centuries?

The question often raised is: If Indians had the questioning attitude and the tradition of experiment and mathematical investigations at one time, and if they made significant contributions to developments in science and technology, especially up to about AD 1200, and maintained their superiority in certain technologies, e.g., textiles, metallurgy, architecture, ship building, etc., right up to seventeenth or eighteenth century,^{6,7,8} why did they fail to build further on this base? Why was it left to Europe to develop

modern science? Were there some factors in our traditions which came in the way?

In history, such questions as to why something did not happen, are difficult to answer. They are even treated as non-questions by some historians. There are several questions of this kind that one could ask about Europe: e.g., why is it that none of the religions of today started in Europe? Why did they all start in Asia? Why did the early wave of science and philosophy in Europe not start in mainland Europe? Why did it start in an insignificant South-Eastern corner of Europe and in adjoining Asia (called *Asia-Minor*)? Why did the Europeans not discover zero and why was Japan relatively late in joining the march of civilizations? and so on. One has no simple and straightforward answers to such questions.

China and the Arab world were also unable to build on the early head-start. Maybe different socio-political and historical circumstances were responsible in each case. These need to be studied in an unprejudiced manner, using such meagre data as are available, and reconstructing where there are gaps (and there *are* many gaps) with a more open mind than is customary. Many times hypotheses were made by western scholars in the colonial period, and these have been echoed by Indian scholars even in the post-Independence era. A kind of colonial thinking has tended to persist, even if unconsciously, and so these hypotheses have to be looked at afresh.

While listing some of the ideological or attitudinal factors which have been held responsible for India's inability to build on its early base, and making some comments on them, we would like to emphasize at the start that they do not strike us as having the status of anything more than speculations or prejudices, given the importance of the question being discussed. Much more detailed work is needed before any of the prevalent myths in this domain could attain the status of causal relationships vis-a-vis development of science in India. Wherever any of the factors have their counter-parts in other civilizations, especially the European civilization, a comparative study would be called for.

It is to be hoped that the relevant sections on philosophy and culture in the volumes that will come out of PHISPC, will deal with these questions in depth.

The Supposed Other-Worldliness of Indian Culture

It is alleged that early Indian culture was otherworldly, that it perceived the world as *Māyā* or illusion, and that the conceptual world-worthlessness led to a lack of interest among Indians in any worldly pursuits. Indians, it is said,

were only interested in the liberation of the soul as a goal, and not in studying the external world.

It may be argued that a distortion of the concept of *Māyā* is involved in such an argument. Even if this is so, it would be useful to know the extent to which the distorted/corrupted interpretations of *Māyā* affected a young intellectual's choice of a field of study, during different epochs of our long history. Were the brightest enquiring minds turned away from the study of worldly phenomena?

Related to the interest in other-worldly entities, was the distinction made between what was called *parā vidyā* and *aparā vidyā*, the higher kind of knowledge and the lower kind of knowledge, and the influence such distinction would have had on the perception of what was really worth studying, and worth respecting.

In the *Muṇḍaka Upaniṣad*, we find the question put by an earnest student to a great teacher: 'What is that reality, by knowing which we can know all that there is in this manifested universe?'⁹ The teacher replies: 'Two are the *vidyās* or sciences, to be acquired by man; so say the knowers of *Brahman*. One is called *parā vidyā*, higher science or knowledge; the other is called *aparā vidyā*, ordinary science or knowledge.'⁹ The knowledge/search for the knowledge of the soul was considered the higher knowledge. Since what was considered *really worth knowing* was to be approached by turning the light inwards, this may have come in the way of the study of the external world. The best minds may have turned towards the exploration of the inner world—toward spiritualism and mysticism—which was placed on a higher pedestal in the name of *parā vidyā*.

Then there was 'a powerful current'¹⁰ in Indian culture that 'the truths of the physical and supra-physical realities can be grasped, known and possessed by us through faculties which lie above the ranges of physical senses and rational intelligence'¹⁰ and that the knowledge obtained by development of those higher faculties by yogic means, through meditation and intuition, is superior to that obtained by one's senses and reason.¹¹ The gods have sometimes been described as *pratyakṣa-dviṣah*, that is as hating something that is acquired by the senses. How powerful was this current in space and time?

It has also been stated that the fact that renunciation was an accepted and respectable way of life fed these trends and came in the way of development of science and technology.

The *Karma* ideology has also been adduced as a cause—the idea of previous births and their consequences in the current life, and the resultant fatalism.

The influence of the *Bhakti-Mārga*, which spread in the country through the emergence of a series of saint-poets after the eighth century in different emergent languages, and their compositions which became very popular, have also been mentioned.

While Indian culture has had such negative tendencies, it is not clear how widespread was their effect in space and time, in a large country and a stratified society, whose intellectual history spanned three to four thousand years—especially as India has many important scientific discoveries to its credit over the centuries. This is a matter that needs to be looked into carefully, from the point of view of possible impact on the development of science. Vivekananda, one of the greatest of the modern exponents of *Yoga* and the *Vedānta*, has for example, laid repeated stress on the experimental character of *Yoga* and on basing it on reason.¹²

Referring to the flourishing trade between India and Rome during the period 200 BC to AD 300, Romila Thapar¹³ mentions Pliny's complaint that the Indian trade was a serious drain on the national income of Rome. The Frenchman Bernier, who travelled in India more than 1500 years later (from 1656 to 1668) says, 'It should not escape notice that gold and silver, after circulating in any other quarter of the globe, come at last to be absorbed in Hindustan'.¹⁴ These are not observations supporting the other-worldliness of Indians, over the centuries.

It is interesting to see what Vivekananda has to say about *Māyā*, especially in relation to scientific pursuits. Vivekananda refers to *Māyā* as 'one of the pillars upon which the *Vedānta* rests'.¹⁵ He, however, warns us that the word *Māyā* is used incorrectly to denote 'illusion or delusion or some such thing'. Having said this, he proceeds to give a number of examples to illustrate what *Māyā* is, a couple of which are quite intriguing:

'A man of science rises, he is thirsting after knowledge. No sacrifice is too great, no struggle too hopeless for him. He moves onward discovering secret after secret of nature, . . . and what for? . . . Why should we give him glory? Why should he acquire fame? Does not nature do infinitely more than any human being can do? Nature can hurl a thunderbolt of any magnitude to any distance. If a man can do one small part as much, we praise him and send him to the skies. Why? Why should we praise him for imitating nature, imitating death, imitating dullness, imitating insentience? . . . Yet we are all struggling after that. And this is *Māyā*.'¹⁶ ' . . . so with our intellect. In our desire to solve the mysteries of the universe, we cannot stop our questioning, we feel we must know and cannot believe that no knowledge is to be gained. A few steps, and there arises the wall of beginning-less and endless time which we cannot surmount. A few steps, and there appears a wall of bound-

less space which cannot be surmounted, and the whole is irrevocably bound in by the walls of cause and effect. We cannot go beyond them. Yet we struggle and still have to struggle. And this is *Māyā*.¹⁷

'... Is there no hope then?' He continues. 'True it is that we are all slaves of *Māyā*, and live in *Māyā*. Is there no way out? no hope? ... on the other side, therefore is the bold assertion that this is all nonsense, that this is *Māyā*. ...'¹⁸

At another place, Vivekananda says, '... the minds of the people from whom the Vedas came were intent upon following principles, discovering principles. They had no time to work upon details or to wait for them, they wanted to go deep into the heart of things. Something beyond was calling them, as it were, and they could not wait. Scattered through the *Upaniṣads*, we find that the details of subjects which we now call modern sciences are often very erroneous, but at the same time their principles are correct. ...'¹⁹

We have chosen to quote at some length from Vivekananda, since he represents in a sense a link between ancient tradition (rather, the *Advaita* tradition) and modernity, and is an important figure in the Indian renaissance towards the end of the last century. Is he also undervaluing the importance of scientific pursuits as we understand them? Do such views reflect the thinking about science in one important school of thought over the centuries? If so, could they have been partly responsible for non-development of modern science in India? In science, what the Swamiji called 'details' are as important as 'principles'; 'details' are in fact an important path to 'principles' and have often led to the overthrow of earlier 'principles'. What does one mean by saying that details were erroneous while principles were correct? In science, no general principle is frozen as unassailable knowledge for all time. The strength of the scientific method is precisely in the openness to new principles in the light of new 'details' as they unfold themselves.

Romila Thapar has noted that 'Indians in the pre-eighteenth century never claimed that they were more spiritual than other peoples, or that the Indian way of life was concerned solely with things spiritual. The ideal of the earlier texts that the best life on earth is a balance between *dharma*, *artha* and *kāma*, shows a healthy unconcern for any obsession with either the spiritual or the material.'²⁰

Works like *Kauṭīliya Arthaśāstra* show the detailed interest taken by ancient Indian scholars in worldly matters of government (which was not dominated by the priesthood) in all its aspects.

Jawaharlal Nehru has remarked 'Probably the Semitic culture, as exemplified in many religions that emerged from it, and certainly Christianity,

was far more other-worldly'. 'Indian culture taken as a whole', he adds, 'never emphasized the negation of life, though some of its philosophies did so; it seems to have done so much less than Christianity'.²¹ Nehru points out that 'in India, we find during every period when her civilization bloomed, an intense joy of life and nature, a pleasure in the act of living, the development of art and music and literature and song and dancing and painting and the theatre, and even a highly sophisticated inquiry into the sex relation. It is inconceivable that a culture or view of life based on other-worldliness or world-worthlessness could have produced all these manifestations of vigorous and varied life. Indeed it should be obvious that any culture that was basically other-worldly could not have carried on for thousands of years. The confusion seems to have arisen from the fact that Indian thought was always laying stress on the ultimate purpose of life. It could never forget the transcendental element in its make-up. . . . It taught detachment in life and action, not abstention from them.'²¹

Romila Thapar has discussed the origin of the stereotype. 'The theory of the instinctive unconcern of Indians for worldly things is found particularly useful in minimising such obvious factors as colonialism in economic underdevelopment. The explanation of Indian economic backwardness does not lie in simplistic generalizations on Hindu culture but demands a detailed investigation into the nature of pre-colonial and colonial society in India.'²²

Claude Alvarez has observed: 'there is still no evidence to date that one line of thought was so dominant that it had become 'orthodox': there was no single established view that set itself up against and above a number of other supposed heresies. The hypothesis that Hindu philosophy (wrongly identified wholly with the idealistic school) proved disastrous for India's technical capacity or economic activity should be relegated to the garbage heap; so too, the fashionable cliché that India spent too much of its energy in the pursuit of metaphysical speculations . . .'.²³

Suppression of the Scientific Spirit for Political Reasons

Debi Prasad Chattopadhyaya²⁴ has argued that there was a systematic suppression of materialists—e.g. the *Cārvāks*—and of materialistic ideologies in ancient India. He has written extensively on this theme, and he, and before him Fillozat, has made a case-study of medicine in ancient India.

Debi Prasad points out that already in the ancient period, some 2500 years ago, Indian medicine had taken the momentous leap from magico-religious therapeutics to rational therapeutics (from *daiva-uyapāśraya-bheṣaja* to *yukti-uyapāśraya-bheṣaja*). This was a very risky step, he says, the risk

involved being political. 'To question even by implication—mysticism, ritualism and religion—necessitates also rejection of the very way of life all these tend to justify. It amounts to questioning the very norm on which a hierarchical society wants to thrive'. Further, the early medical men were looking for material, natural causes of diseases. Chattopadhyaya argues²⁵ that 'The view of the laws inherent in nature—technically called *svabhāva*—is essential for *Āyurveda*. Thus the fundamental postulates of ancient Indian medicine are:

- (i) everything in nature takes place according to laws inherent in nature;
- (ii) though immutable, these laws are nevertheless knowable;
- (iii) the knowledge of these laws brings power over nature, which medically means ensuring a long and healthy life.'

This emphasis on *svabhāva* rejects *adr̥ṣṭavāda* or *karmavāda* or any supernaturalism. Chattopadhyaya argues that this natural cause and effect approach to human ailments and their treatment was considered subversive by the priests and the Indian law-givers were 'obliged to denounce it as abject heresy'. This led to the downgrading of the practitioners of medicine in the social hierarchy, by the law-givers, and also to interpolations of theological/philosophical discussions in the *Caraka-saṃhitā*, which are inconsistent with its rational spirit.²⁶

The conflict between science and the counter-ideology was also present in Europe in the middle ages. There was the Inquisition, the burning at the stake of non-conformist thinkers like Giordano Bruno, the trial and humiliation of Galileo, and the indexing of books. How does one compare the conflict between science and the counter-ideology in India with that in Europe? Why was it that the counter-ideology could prevail in India, whereas Europe could get over its influence?

Is the argument of Chattopadhyaya regarding suppression of materialism in relation to Indian medicine overdrawn? It would be useful to have a fresh look at it. Medicine did thrive in India, did make advances²⁷ and even spread outside India down to the eighth century. Indian doctors were imported by the Abbasid Khalifas to supervise their own hospitals in the eighth century AD and Sanskrit medical texts were translated into Arabic.²⁸

A Spanish-Muslim scholar, quoted by Debi Prasad himself, says in AD 1080 that Indian medicine was the best in the world.

Further, when Francis Buchanan carried out a survey of the state of medicine and surgery in 1807, under orders from the Court of Directors of the East India Company, he observed in relation to Bihar: 'Medicine is

*taught by several of the Pandits, some of whom also, though they are grammarians, practice the art. . . . Besides the Professors of Medicine, about 700 families of Brahmins, almost all of Śakadwip, practice that art and are the only Hindu physicians who possess anything like science. . . .*²⁹ (emphasis added).

Conflict between Science and Religion

It is not unusual to come across the claim that unlike in Europe, there was no conflict between science and religion in India,^{30,31} because there was no hostility to science or new ideas in philosophy, on the part of religion; that even atheists were not persecuted in India. This was true in early times when there was full intellectual freedom, a beautiful example of openness being the *Nāsadiya sūkta* in the *Rgveda*. There were as many as sixty-three systems of philosophy in the days of the Buddha and very few of them cared to rely on Vedic authority for their hypotheses or their conclusions. Within the fold of the orthodoxy itself there were the *Sāṃkhya*, *Mīmāṃsā* and *Nyāya* systems, which had hardly any appropriate place for the divine Creator in them. Buddhism and Jainism were not summarily dismissed as atheistic. But certain works came to be canonized some time around 600 BC, and an almost equal reverence came to be paid to the *Smṛtis* and *Purāṇas* in course of time. Theories began to be accepted or rejected according as they were in conformity with or opposed to statements of the sacred books.³² Already by the time of Śāṅkara, the pressure was quite strong. Intellectual giants like Śāṅkara and Rāmānuja had to spend a disproportionate amount of time and energy to prove that their systems of philosophy were in conformity with and the natural outcomes of the Upaniṣadic hypotheses. Independent development of philosophies was affected. Instead one only had commentaries on the revealed literature.³²

The separation of philosophy from theology, and of science from philosophy, also did not take place. The separation would seem to have been an important step in European developments. It enabled science to go ahead when theology and metaphysics stagnated.

Under such circumstances, there was not much scope left for research and originality in those matters where opinions were expressed in the sacred books, which now included *Smṛtis* and *Purāṇas*. A glaring example is that of the mythological stories about *Rāhu* and *Ketu* temporarily overpowering the moon or the sun and thereby causing eclipses, which got canonized by inclusion in the *Purāṇas*. Āryabhaṭa (c. AD 500), Varāhamihira and Brahmagupta (c. AD 600) knew the scientific explanation of eclipses but were powerless to explode the myths. In fact, Brahmagupta went to the extent of condemning Āryabhaṭa, Varāhamihira, Śriṣeṇa and Viṣṇucandra for ex-

pounding the unorthodox but scientific theory of eclipses. Alberuni has suggested that Brahmagupta made the compromise because a calamitous fate like that of Socrates had befallen him.³³

Was this also the reason why Āryabhaṭa's suggestion that the earth revolves around its axis was not followed up by later astronomers? or for the fact, that the idea of impetus could not develop into inertia, force etc.—perhaps the most important developments in Europe that launched the scientific revolution?

Incidentally, it will be useful to have more light thrown on the process of canonization of scriptures, including the Smṛtis and the Purāṇas, which made it impossible for even outstanding intellectuals like Brahmagupta to counter stories like those of *Rāhu*, *Ketu* and the eclipses; also, to document other instances of this kind. Is the view that there was no conflict between science and religion/spirituality, a modern view, or does it go back to ancient times?

Swami Ranganathananda³⁴ quotes from Śankarācārya's commentary on the *Bṛhadāraṇyaka Upaniṣad*: 'Nor are the Śrūtis (the Vedas) supposed to have authority in matters which are contradicted by other means of knowledge, as for instance, if they said, "Fire is cold and wets things" '. Was such thinking widely accepted, by scholars or people at large? And, if yes, during which epochs?

Possibly connected with this concept of knowledge as captured and frozen in the scriptures, is the picture of a traditional Brahmin scholar today as a repository of knowledge in the books—rather than a free-wheeling creative intellectual, applying his knowledge to the exploration of new phenomena, or providing improved explanations of phenomena already known. When did the tradition of questioning, as in the Upaniṣads and *Nyāya-Vaiśeṣika* and other texts, lose its vigour and a static view of learning of the learned emerge?

The Belief that all Knowledge is in the Vedas

Vivekananda refers to the belief prevalent in India that all that is called knowledge is in the Vedas.³⁵

It is not uncommon to find it claimed even today that the Vedas are the storehouse of all knowledge—*spiritual and secular*. For example, Jagadguru Swami Shri Bharati Krishna Maharaj has said:

The very word *Veda* has this derivational meaning, i.e. the fountainhead and illimitable store-house of all knowledge. This derivation, in effect, means, connotes and implies that the *Vedas* should contain within themselves all the knowledge needed by

mankind relating not only to the so-called spiritual (or other-worldly) matters but also to those usually described as purely secular, temporal or worldly, and also to the means required by humanity as such for the achievement of all-round, complete and perfect success in all conceivable directions and that there can be no adjectival or restrictive epithet calculated (or tending) to limit that knowledge down in any sphere, any direction or any respect whatsoever.

In other words, it connotes and implies that our ancient Indian Vedic lore should be all-round, complete and perfect and be able to throw the fullest necessary light on all matters which any inspiring seeker after knowledge can possibly seek to be enlightened on.³⁶ (emphasis added)

One should note that this statement of the Jagadguru is quoted by a former President of the Association of Indian Universities, in his Foreword to the book *Science and the Vedas*.

It will be useful to know how old is this kind of belief in our cultural/philosophical history. When and how did it get ascendancy? Such a belief, if widely held, could lead to stagnation or even decline in science, and could therefore be an important factor inhibiting the growth of modern science in India. It could also have inhibited the healthy development of philosophy.

Tendency to Accommodate Conflicting Opposites

Indian tendency to accommodate conflicting opposites has been mentioned as one of the causes. The faith of some of our modern scientists in miracle-making god-men is cited as a present day example.

Alberuni, the scholar-traveller who visited India around AD 1000 was very critical of the Hindus on this score: '... you mostly find that even the so-called scientific theorems of the Hindus are in a state of utter confusion, devoid of any logical order, and in the last instance always mixed up with silly notions of the crowd, e.g., immense numbers, enormous spaces of time, and all kinds of religious dogmas, which the vulgar belief does not admit of being called into question. Therefore it is a prevailing practice among the Hindus *jurare in verba magistri*; and I can only compare their mathematical and astronomical literature, as far as I know it, to a mixture of pearl shells and sour dates, or of pearls and dung, or of costly crystals and common pebbles. Both kinds of things are equal in their eyes, since they cannot raise themselves, to the methods of a strictly scientific deduction. . . .'³⁷

These are harsh words, possibly coloured to some extent by the arrogance of a person accompanying conquering Mahmud, but they should make us look introspectively at the cultural and philosophical milieu of that period.

Varāhamihira wrote in *Bṛahatsaṃhitā* that the gems could have origi-

nated either from the bones of gods and demons, or on account of natural metamorphosis of rocks. The possibilities were given equal emphasis. Biswas gives more revolting examples from *Rasa-Ratna-Samuccaya*, a thirteenth century text.³⁸

D.D. Kosambi has observed: "The 'logic' advanced by the brahmins took good care to avoid all reality. The end result is seen in the philosophy of the great Śankara (AD 800), who threw out the proposition that "A thing is either A or non-A", and viewed the universe as divided into metaphysical categories upon several planes. The highest plane was, of course, of speculation about and unity with eternal principles. Material reality did not exist. The philosopher was thus excused if he joined the common herd on the plane of ritual observation . . .".³⁹

An oft-quoted example of this tendency as far as science is concerned is that Brahmagupta wrote the popular myth about the cause of eclipses (*Rāhu*, *Ketu* and all that) along with his calculation in terms of the correct astronomical explanation.

It is interesting to see what Meghnad Saha has said in this regard: '... in India, the votaries of the astronomical science apparently found it difficult to go against the scriptures. The Greek savants, with characteristic boldness and freedom of thought, had pooh-poohed the Homeric and Hesiodic cosmogony, they made light of the Olympic Gods. But the Indian savant never showed equal boldness. On the other hand, being accustomed to easy-going pantheistic tendencies, he was always ready to compromise and be accommodating in his views . . . never courageous enough to propose a bolder theory of the universe in opposition to current ideas. Āryabhaṭa of Kusumpur (Patliputra) (born in AD 476) thought that earth, by turning round its axis caused day and night, but his successors did not seem to be impressed with his ideas. It is, however, clear that they were keenly alive to the stupidity of public beliefs or utter inadequacy of the *śāstric* lore. 'It is said' says Bhāskarācārya "that the earth rests on the hood of a huge snake, which when it feels uneasy gives a shake and causes earthquakes. Well, the snake must have something to rest upon, let it be the tortoise, but this also must have something else to rest upon. So we have to assume the hypothesis of an endless string of the supported and supporters. A better explanation would be that the earth has no support, i.e. is suspended in space." But in the next sentence, he is careful to say, "but since these things are mentioned in the *Śāstras*, there must be some truth in them".'⁴⁰

Lest we are too harsh on Brahmagupta or Bhāskarācārya, we may note what Stephen Jay Gould⁴¹ has to say about Newton and Whiston, his successor as Lucasian Professor at Cambridge: "The Newton of our Pantheon

is a sanitized and modern version of the man himself'.⁴¹ Newton greatly admired the book *New Theory* by William Whiston (1696), to such an extent that Whiston ended up as Newton's handpicked successor as Lucasian Professor of Mathematics at Cambridge. The full title of Whiston's treatise gives an idea of its contents. Whiston called his treatise *A New Theory of the Earth from its Origin to the Consummation of all Things, Wherein the Creation of the World in Six Days, the Universal Deluge, and the General Conflagration, as laid down in the Holy Scriptures, are shown to be perfectly agreeable to Reason and Philosophy*.

In trying to establish a consistency between the two great sources of truth as defined by his countrymen—the infallibility of the scriptures, and the mathematical beauty of the cosmos, so recently recreated by Newton—Whiston implicated comets as prime movers.

'Whiston has descended through history' remarks Gould, 'as the worst example of religious superstition viewed as an impediment to science'. '... We dismiss Whiston because he violated ideals of science as we now define the term. But, in Whiston's time, science did not exist as a separate domain of inquiry; the word itself had not been coined. No matter how we may view such an enterprise today, Whiston's mixture of natural events and scriptural traditions defined a primary domain at the forefront of scholarship in his time. . . . He did not view his effort as a work of science, but as a treatise in an important contemporary tradition for using all domains of knowledge—revelations of Scripture, history of ancient chronicles, and knowledge of nature's laws—to reconstruct the story of human life on our planet. The *New Theory* contains—and by Whiston's explicit design—far more material on theological principles and biblical exegesis than on anything that would now pass muster as science'.⁴¹

The interesting thing in the context of our discussion is the fact that Whiston's work was highly thought of by no less a person than Newton.

It is also well known that at the same time that Newton was working on the *Principia*, he was also spending a substantial fraction of his time on investigations in alchemy and theology. On the other hand, he did not publish anything on either of these subjects.

Complacency developed during the Period when the Indians had attained a high Level of Civilization

Another line of reasoning puts the blame on the complacency that the Indians had developed over a period of time: they began to think that they had attained the highest knowledge that humans were capable of and they

progressively lost the questioning attitude and openness to knowledge from other sources (*ā no bhadrāḥ kratavo yantu viśvataḥ*). In this context one often quotes Alberuni, who says the following about the attitude of Hindus of his time:

They are haughty, foolish, vain, stolid and self-conceited. According to their belief, there is no other country on earth but theirs, no other race of man but theirs, and no created beings besides them have any knowledge or science whatsoever. Their haughtiness is such that, if you tell them of any science or scholar in Khurasan or Persis, they will think you to be both an ignoramus and a liar. *If they travelled and mixed with other nations, they would soon change their mind, for their ancestors were not as narrowminded as the present generation is*⁴² (emphasis added).

Gārgi Saṃhitā says: 'The *yavanas* (i.e. the Greeks) are indeed barbarians, but astronomy originated in them and for this they must be venerated as Gods'.⁴³

Āryabhaṭa and Varāhamihira also did not have the attitude described by Alberuni, though one probably sees the beginning of such an arrogant and exclusive attitude in Varāhamihira when he says: 'The Greeks, *though impure*, must be honoured, since they were trained in sciences, and therein excelled others. *What then, are we to say of a Brahman, if he combines with his purity the height of science?*'⁴⁴ (emphasis added).

When did the vain, self-conceited attitude start dominating? How did it continue in spite of the humiliating defeats that the Hindu society had to accept from successive invaders?

The complacency or intellectual lethargy that had developed, continued even after the Moguls came to power. Jawaharlal Nehru refers to the curious fact that Akbar did not take any interest in building sea-power, though Vasco de Gama had reached Calicut, via Cape, in 1498, and established Portuguese sea power in the Indian Ocean. What is more, this lack of interest continued even after the Portuguese started exacting tolls from traders and from pilgrims going to Mecca. He or the 'jewels' in his court, also took no interest in printing,⁴⁵ though the Jesuits presented him with a printed Bible. The Mogul army and the armies of other states in India depended on foreign experts for their artilleries. Why did Akbar or anyone else not send his own men abroad for training, or interest himself in the improvement of the artillery by encouraging research work? Why did they not take interest in developing Indian clocks, though imported clocks were very popular with the Mogul nobility?

Over the centuries, during the Gupta period and later, India imported horses from Arabia, Iran and Bactria. For some strange reason, India never

took to the breeding of horses and training the veterinaries. Mentioning this, Romila Thapar remarks 'The fact that India never bred sufficient horses of quality, the best blood having always to be imported, was to have disastrous consequences on the cavalry arm of Indian armies, eventually making the cavalry ineffective, especially in comparison with Central Asian hordes'.⁴⁶

Rigidity of the Caste System

A factor that needs some discussion is the growing rigidity of the caste-system in India which led to the separation of the head from the hand.⁴⁷ Theoretical and philosophical studies (including the speculative aspects of science) were the prerogative of the Brahmins, whereas the practical arts and crafts were relegated to the other castes. These lower castes, moreover, did not have the benefit of formal education. This prevented the coordination between science and crafts, and theory and experimentation/experience. Also, the accumulated theoretical knowledge was accessible to Brahmins in Sanskrit while the common technicians, who knew only one of the Prakrits, had no access to it. It would be useful to compare and contrast with the similar problem in medieval Europe, where the accumulated theoretical knowledge was a prerogative of the Latin-knowing clergy and aristocracy and not accessible to common artisans. Also, when did the caste-system become rigid from the point of view of separation of the head from the hand? Altekar observes that after AD 800, primary education became restricted to the higher strata of society; the vast majority of workmen and artisans became illiterate by this time and knew only the traditional processes of their profession.⁴⁸

The Ban on Foreign Travel

Foreign travel seems to have got banned around the eighth century.⁴⁹ This is usually attributed to the increasing rigidity of the caste system, and the ideas of purity and pollution, especially in relation to mixing with foreigners and observing food taboos. Vivekananda in one discussion attributes the ban to a desire to prevent the Hindus from mixing with the surrounding Buddhistic nations. He says: 'The one great cause of the downfall and degeneration of India was the building of a wall of custom—whose foundation was hatred of others—round the nation, and the real aim of which in ancient times was to prevent the Hindus from coming into contact with the surrounding Buddhistic nations.'⁵¹

Whatever be the cause, banning of foreign travel could not but have a very adverse impact on the exposure to fresh ideas and new techniques, so

essential for growth of science. V.N. Sharma⁵² has discussed the possibility that Raja Jai Singh may have received wrong advice from his foreign consultants, the Jesuits, with regard to the state-of-art in Astronomy in Europe. Though their delegation visited Europe on his behalf, the Jesuits, because of their own theological beliefs and prejudices, may not have presented the Copernican revolution to Jai Singh in its true perspective. The European books which Jai Singh got translated into Sanskrit included the already obsolete *Almagest* of Ptolemy and not *On the Revolution of the Heavenly Spheres* of Copernicus or *The Harmonies of the World* of Kepler or *Dialogues Concerning Two New Sciences* of Galileo or *The Principia* of Newton, all of which had been in existence for quite some time. Jai Singh also does not seem to have benefited from the developments in telescopes taking place in Europe, in planning his observatories. 'Unfortunately', says Sharma, 'The Raja seemed to have had no alternative but to send a team of foreigners on his fact-finding mission in Europe as no high-born Hindu of his days would dare "cross the ocean" and thereby risk "losing his caste"'.⁵² This unfortunate predicament of the Raja need not diminish our admiration for his vision and his contributions to astronomy.

A Handicap of the Oral Tradition?

The Indian tradition is said to have been largely an oral tradition, from the earliest times when the Vedas were not written but passed on by recitation from the *Guru* to the disciple, with explanations in the course of the transfer. Later when writing was developed (c. 400 BC), the style was usually aphoristic, so that the intermediary of a *Guru* was needed for an understanding of the meaning of the esoteric texts. While commentaries helped to some extent, they often did not throw light on the rationale of the problem tackled or provide an insight into the mental working of the scientist whose results were given cryptically in a *sūtra*. Added to this was the secretive aspect of the tradition, which again meant that if the symbolic language with secret meaning, or *récipé*, or special formula was not transferred by a *Guru* to his (favourite) *śiṣya*, that piece of knowledge disappeared.⁵³

Effect of Invasions?

Successive invasions meant not only devastating destabilization of the functioning of society and loss of prosperity, it also meant loss of centres of learning, including their libraries. Alberuni describes the effect of Sultan Mahmud's invasions: '... Mahmud utterly ruined the prosperity of the country, and performed there wonderful exploits, by which the Hindus became like atoms of dust, scattered in all directions, and like a tale of old in the

mouth of people. . . . This is the reason why Hindu sciences have retired far away from those parts of the country conquered by us, and have fled to places which our hand cannot yet reach. . . .'

India had at one time flourishing universities at Takṣaśilā, Vikramaśila, Valabhi, Nālandā, etc. Within a couple of hundred years of the above account by Alberuni, the 700–800 years old university of Nālandā, to which scholars came from various parts of the country and from abroad, was destroyed by Bakhtiyar Khilji. Bakhtiyar Khilji also destroyed the famous university of Vikramaśila and Odaṇḍapurī. These were the last of the great Indian universities to disappear. No great universities came up in the centuries that followed, either under the Afghans and the Moguls in the north, or under the Vijayanagar and other kingdoms of the south.

One may say that one had the *Gurukul* system. But such a *gharāṇā* system had its weak as well as strong points. It could not be a substitute for universities.

It would not be an accident that the bright period for Indian science and philosophy was also the period in which some of these universities flourished and attracted scholars from far-off places. One notes in this context the role played by the universities of Cordova, Cracow, Tübingen, Paris, Oxford, Bologna and Padova in the revival of learning (science in particular) in Europe. Some of the great architects of the scientific revolution in Europe had been at Padova at important periods in their career—Copernicus, Galileo, Harvey, and Vesalius to mention a few.

Even the great Akbar does not seem have applied his mind to the setting up of universities. Why?

Just around the time when India's great universities were disappearing, new universities were coming up in Europe.⁵⁴ This was followed by the setting up of Academies/Royal Societies which also were to play an important role in the intellectual life of Europe.

The effect of centuries of unsettled conditions that prevailed before a multi-religious composite culture could emerge, needs to be analysed dispassionately without allowing either Hindu or Muslim chauvinism to distort the view of the happenings.

The British had stepped in before India could find its feet again.

Influence of Buddhism?

Going back to an earlier period, what were the positive and negative impacts of Buddhism on the development of science in India? The Buddha himself stressed the importance of the spirit of enquiry:

Believe nothing
 Merely because you have been told it,
 Or because it is traditional,
 Or because you yourself have imagined it.
 Do not believe what your teacher tells you,
 Merely out of respect for the teacher.
 But whatever, after due examination and analysis,
 Your find to be conducive to the good,
 The benefit,
 The welfare of all beings,
 That doctrine believe and cling to,
 And take it as your guide.

It is interesting that he said this around the time that some of the Hindu scriptures were getting canonized. Can one trace the healthy impact of this on science?

Later, things changed. As Chattopadhyaya points out in the course of his discussion of the vicissitudes of Āyurveda, while the concept of causality is absolutely crucial for Āyurveda, Nāgārjuna, the founder/exponent of the *Mādhyamaka* school of philosophy, popularly known as *Śūnyavāda*, denied causality and condemned experience and reason as sources of right knowledge. What impact did this have on science?

It is curious that the decline of Indian science seems to have started around the time or in the centuries following the victory of Ādi Śankara over the existing Buddhistic doctrines and other materialistic and non-materialistic schools of Indian philosophy in the eighth century. Did this victory imply the re-establishment of spirit over matter, leading to a down-grading of creative science?⁵⁵

Did the *Prāmāṇyavāda* which followed in succeeding centuries have an adverse effect?

One hopes that an objective discussion of the positive and negative impacts will be forthcoming.⁵⁶

Too Big a Load from the Past?

Was the continuity in Indian civilization a handicap? Europe lost its Graeco-Roman knowledge and tradition in the dark ages, and then recovered these a thousand years later through the Arabs, along with the knowledge which the Arabs brought from India. When this happened, the Europeans had a chance to have a fresh critical look at the old heritage. Such a critical look started already in the thirteenth to fourteenth centuries with the scholastics, and was an important factor leading to Renaissance. Was the absence of discontinuity a disadvantage for the Chinese and the Indians?

The load from the past has been summarized by Kosambi: 'The absence of logic, contempt for mundane reality, the inability to work at manual and menial tasks, emphasis upon learning basic formulas by rote, with the secret meaning to be expounded by a high *guru*, and respect for tradition (no matter how silly) backed by fictitious ancient authority, had a devastating effect upon Indian science'.⁵⁷

The various corrosive factors seem to have been operating from the last centuries of the first millennium, though their effect was seen much later. As Jawaharlal Nehru has remarked, during Akbar's time, 'India to all outward seeming, presented the spectacle of not only a brilliant court, but of thriving trade, commerce, manufacture, and crafts. In many respects, the countries of Europe would have seemed backward and rather crude to an Indian visitor then. And yet the dynamic quality which was becoming evident in Europe was almost wholly absent in India. . . . A civilization decays much more from inner failure than from external attack. It may fail because in a sense it has worked itself out and has nothing more to offer to a changing world, or because the people who represent it deteriorate in quality and can no longer support the burden worthily. . . .'⁵⁸

Rise of Modern Science in Europe

Finally, it may be appropriate to comment very briefly on some of the contributory factors that are often mentioned in the context of the rise of modern science in Europe.

Rise of modern science was a unique happening that took place in Europe. There has been a lot of post-facto rationalisation of this development.⁵⁹ The search has been for developments which took place uniquely in Europe, so as to make a case that modern science could arise only as a concomitant of such developments and therefore in Europe and nowhere else. Developments like reformation, renaissance are often mentioned as contributory or triggering factors. It is good to remember, however, that Copernicus was not only a Catholic but a canon in the Roman Catholic Church and that high dignitaries of the Church were associated with the publication of his book. Galileo was also a Roman Catholic and ventured into the realm of theology by attempting to show that the Copernican system was consistent with a fair interpretation of the words of the scripture. And Martin Luther mounted a vicious attack on Copernicus. The Catholic Church, it is well known, put the books of Copernicus and Galileo on the *Index*.

Anthony,⁶⁰ a biographer of Newton, quotes Butterfield to make the point that the ancient Greek thought, through Arab translations, renaissance,

reformation, etc. did not change the mode of thinking of people as scientific revolution itself did.

Butterfield has, in fact, observed, 'Since that (i.e. scientific) revolution overturned the authority in science not only of the middle ages but of the ancient world—since it ended not only in the eclipse of scholastic philosophy but in the destruction of Aristotelian physics—it outshines everything since the rise of Christianity and reduces the renaissance and reformation to the rank of mere episodes, mere internal displacements within the system of medieval Christendom . . .'.⁶¹

The question then arises if one has been overemphasizing factors like renaissance, reformation and changes in the mode of thinking of people as the prime contributors to the rise of modern science in Europe.

And Bertrand Russell has observed:

'Although science was what interested (Francis) Bacon, and although his general outlook was scientific, he missed most of what was being done in science in his day. He rejected Copernican theory,' even after the work of Kepler. 'Bacon appears not to have known of the work of Vesalius, the pioneer of modern anatomy or of Gilbert, whose work on magnetism brilliantly illustrated inductive method. Still more surprising, he seemed unconscious of the work of Harvey, although Harvey was his medical attendant!'.⁶²

It is also interesting to note the comments of Thomas Huxley on the influence of Baconian philosophy:

. . . I do protest that, of the vast number of cants in this world, there are none, to my mind, so contemptible as the pseudo-scientific cant which is talked about the Baconian philosophy. To hear people talk about the great chancellor—and a very great man he certainly was—you would think that it was he who invented science, and that there was no such thing as sound reasoning before the time of queen Elizabeth. . . . The method of scientific enquiry (did not originate with Bacon or his age) originated with the first man whoever he was. . . .⁶³

Butterfield has commented that one of the aspects of history not sufficiently emphasized is that '*From the fourth to the twentieth century, one of the most remarkable aspects of the story—the most impressive conflict that spans fifteen hundred years—is the conflict between Europe and Asia, a conflict in which down to the time of Newton's Principia, it was the Asiatics who were on the aggressive.*'⁶⁴

It is clear that some of the contributory factors held responsible for the rise of modern science in the West and for the East lagging behind, need a fresh look.

P.K. Mukhopadhyay⁶⁵ has written about two metamorphoses of the mind, in recent centuries, one among the Europeans who appropriated science as a purely western product, as a most typical creation of thought of the Western civilization, and the other suffered by the colonial people, Indians in particular, which persuaded them that science was not a part of their civilization. Mukhopadhyay's thesis calls for a closer look.

Concluding Remarks

It should be clear that the Project on the History of Indian Science, Philosophy and Culture, should constantly keep in view the changing socio-cultural-philosophical milieu in which science could flourish in India during certain periods, and in which Indian technology could be at the forefront internationally in certain domains down to the eighteenth century, and in which both became stagnant or declined during other periods. What were the external factors and what were the internal failures, *which must not be allowed to repeat*? Were the internal failures on a broad front (science, philosophy, literature, art and architecture...)? To the extent that the Project will succeed in unraveling these complex intertwining factors, it will provide a landmark in the history of the development of Indian science, philosophy and culture.

The author would like to thank B.V. Subbarayappa for a critical reading of the manuscript, and discussions on it.

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14. François Bernier, quoted by B.V. Subbarayappa in Reference 5, p. 485.
15. Swami Vivekananda, *Jñāna-Yoga* (Advaita Ashrama, Calcutta, 15th edn, 1980), p. 47.
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18. Ibid., pp. 98–9.
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26. E.g. reference 24.
27. Unfortunately, soon after *Suśruta*'s time, dissection of human bodies went out of vogue, to the great detriment of the progress of medical science (ref. 28, p. 178).
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30. E.g. Swami Ranganathananda, *Science and Spirituality* (Ramakrishna Math, Hyderabad, 1982), also *Science and Religion* (Advaita Ashram, Calcutta, 1982).
31. It is not our intention to belittle the valuable efforts being made by Swami Ranganathananda to build bridges between religion and spirituality on the one hand, and science on the other, in the context of modern needs. The question, however, is what happened in history.
32. A.S. Altekar, loc. cit., pp. 342–6. Altekar also discusses the narrowness that developed in the educational system over the centuries.
33. Alberuni in *Alberuni's India*, Ed Edward Sachau (Popular Edition, 1914), vol. II, p. 112.
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35. *Jñāna-Yoga*, loc. cit., p. 166.
36. Jagadguru Swāmi Bhārati Kṛīṣṇa Mahārāj, quoted in the Editor's Foreword to *Sciences and the Vedas*, Ed. Ishwarbhai Patel, Former President, Association of Indian Universities (Somaiya Publications, 1984).

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42. Alberuni in *Alberuni's India*, loc. cit., vol. 1, p. 22. Note, however, that Alberuni has elsewhere praised the Hindus and their contributions to the sciences. He even learnt Sanskrit and translated some of the works in Sanskrit.
43. Quoted by R.C. Majumdar, 'India and the Western World', in *History and Culture of Indian People* (Bharatiya Vidya Bhavan), vol. II, chp. XXIV.
44. Varāhamihira, quoted by Alberuni in reference 33, pp. 22-3.
45. Daniel J. Boorstein has drawn attention to the fact that 'despite an uncanny reverence for the written word, the Arabic world resisted the opportunities of the printing press', and remarks that 'fear of blasphemy and heterodoxy kept the printing press out of the Muslim world for centuries.' See Daniel J. Boorstein, *The Discoverers* (Vintage Books, 1985), pp. 539-47 for details.
46. Romila Thapar, *A History of India*, loc. cit., p. 149.
47. B.V. Subbarayappa, ref. 5, pp. 484-5.
48. A.S. Altekar, loc. cit., p. 198.
49. How effective was the ban until the thirteenth century? Until then, Indians had close interaction with West/Central Asia and S.E. Asia (Irfan Habib, Ref. 50). And it could not have affected Muslim scholars and traders? The Gujeratis were, in fact, the dominant ship-owning and trading community at Malacca at the end of the fifteenth century (see, for example, *The Suma Oriental of Tomé Pires*, Hakluyt Society, London, 1944, 2 vols, translated and edited by Armando Cortesão, quoted in *South-East Asia: Its Historical Development*, by John F. Cady, Tata-McGraw Hill, New Delhi, 1976).
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51. Śwami Vivekananda, *Teachings of Swami Vivekananda* (Advaita Ashram, Calcutta, 1971, 5th edition), p. 154.
52. Virendra N. Sharma, *Ind. Journ. of Hist. of Sc.*, 18(1), 333 and 345, 1982.
53. It is a pleasure to thank B.V. Subbarayappa for a discussion on the contents of this paragraph.
54. It is interesting to read the announcement of the founding of a new University at Toulouse in 1229, which made a special mention that 'Those who wish to scrutinize the bosom of nature to the inmost can hear here the books of Aristotle which were forbidden at Paris', ref. 'New University-1229' in *A Random Walk in Science* (Institute of Physics, London, 1973), p. 15, the item being condensed from *University Records of the Middle Ages*, by Lynn Thorndike (Columbia University Press, 1944).
55. Cf. P.C. Ray in this context: 'The Vedānta philosophy, as modified and expounded by Śāṅkara, which teaches the unreality of the material world is to a large extent responsible

for bringing the study of physical science into disrepute. Śankara is unsparing in his stricture on Kaṇāda and his system. . . . Among the people ridden by caste and injunctions of the *Vedas*, *Purāṇas* and *Smṛtis* and the like, cramped and paralysed, no Boyle could arise.' (quoted by Debi Prasad Chattopadhyaya in ref. 3).

56. See S.N. Sen, ref. 4, for a brief discussion.
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History of Chemistry and Alchemy in India: From Pre-historic to Pre-modern Times

VIJAYA J. DESHPANDE

INTRODUCTION

The origins of Indian chemistry lie in the earliest use of various materials to make articles of everyday need such as pottery, bricks, metalware, etc. From there it progressed through ages to develop into a highly advanced metallurgy which produced a number of alloys like bronze, brass and bell-metal; rust-free iron as in the iron-pillars of Delhi and Dhar, extra-hard Wootz steel from which swords and other sharp-edged weapons were made in India as well as in foreign countries. Other useful chemical arts and crafts which originated in the pre-historic and vedic times also flowered in the medieval period. Rise of alchemy in the late medieval period saw the theoretical and experimental side of Indian chemistry. In short, the story of Indian chemistry is the narration of a glorious early start of chemical activity with a vibrant period in the medieval times which came to a standstill by the seventeenth century AD. It was revived in the late nineteenth century after the exposure to modern chemistry and other sciences, of the newly English-educated class of scholars. It is not a complete story since a lot of historical material remains to be explored and the available material is not completely studied.

There are three modes of investigating the sciences and technologies of the past, first is through archaeology, second is through the literary records and the third is the study of techniques in the areas where a continuous tradition existed till recent times. All the three are taken recourse of for providing definite inferences. Archaeological findings tell us

about the time, place and pattern of chemical practices whereas archaeological studies inform us about the materials, their compositions and also the techniques employed. Literary sources provide not only definite dates of particular events in the development but also the socio-economic, religious-philosophical matrix into which these originated.

In the Indian context written records are available from the vedic age which is dated back to 1700 BC. *Rgveda* being the earliest of Vedas, becomes the earliest literary source. Then come the Brāhmaṇas, Purāṇas and Upaniṣads, which tell a great deal about the vedic and post-vedic pattern of life. For pre-vedic history we have to rely only on the archaeological findings. Mohenjo-daro and Harappa, which form part of present-day Pakistan, were the earliest excavated sites. Excavations at these places began rigorously in early twentieth century. Artifacts found here and also the remains of the settlements throw much light on the civilization that flourished on the banks of river Indus or Sindhu, Ravi; and Kalibangan on Saraswati, and lasted over a millennium from 2500 BC to 1500 BC.

From the pre-historic times, through vedic (1700 BC to 500 BC), post-vedic or Buddhist period (500 BC to AD 600), the path of chemical development was simple, essentially that of accumulating factual knowledge through metallurgy and other chemical arts and crafts. There was hardly any attempt to give explanations for the observed processes or inventing new processes. During the Tantrik or alchemical period (AD 700 to AD 1300) on the other hand, we observe a merger of hands and brains in the sense that specific goals, viz. gold and silver-making were marked and experiments were carried out to achieve them. Thus Indian chemistry broke fresh ground during the alchemical period. Alchemical experiments were on a small scale since they involved the use of very pure substances including precious metals. The alchemist tried to explain the observed phenomena with the help of the then established alchemical theory. These experiments were carried out by the learned people who were experts of Āyurveda; which is the ancient Indian medical system. During their endeavour, the alchemists discovered a number of substances and processes and established primacy of India with respect to these discoveries. The most distinguishing feature of this period is that the details of the experiments were zealously noted down for the first time in Indian history. It included ingredients, their measures, and successive operations. Though alchemical products were rarely preserved, the theory and practice is well-manifest in the medieval alchemical texts and important aspects of medieval chemistry could be studied through them.

Even though Indian alchemical theory was discredited in the course of

time, as it was in other parts of the world, chemical arts and crafts continued to develop during this period. These two independent activities reinforced each other through the accumulation of more and more factual knowledge. It directly or indirectly helped to form the basis of the modern science of chemistry which evolved during the later stages of the western scientific revolution, which itself emerged as a concurrence of a number of favourable factors in seventeenth-eighteenth century Europe. It is hardly logical to say that India could have formed the seat of scientific revolution if the political and consequent economic factors were not adverse. Yet a favourable situation could certainly have led to large, economically sound chemical industries which were nipped in the bud by adverse policies of the foreign rule.

A number of scholars consider it meaningless to brand the ancient and medieval chemical practices as successes or failures in the light of modern science. They prefer to consider them as successes if they answered the necessities of time. On our part, it would be worthwhile to judge them with respect to both; their usefulness in the contemporary context and also their drawbacks which hindered their transformation into modern science of chemistry.

With the above considerations the story of Indian chemistry and Alchemy could be divided into four parts.

1. History of chemistry in India from pre-historic to pre-Tantric period (up to AD 600)
2. Chemical arts and crafts.
3. History of alchemy.
4. The later development.

In the following pages these topics are taken up one after the other to provide an account of chemistry and alchemy in India since pre-historic times. Recent researches in the fields of archaeology, history of chemistry and metallurgy are included in this account, as far as possible.

I

HISTORY OF CHEMISTRY IN INDIA FROM PRE-HISTORIC TO PRE-TANTRIC PERIOD (UP TO AD 600)

Pre-Vedic Period including Indus Valley Civilization

Indus valley settlements being the earliest, which could be distinguished from the earlier settlements in having a uniform civilized pattern of habitat depicted in the remains of streets, public baths, temples, granaries; as well

as in the mass production of a particular kind of pottery; houses of baked bricks and especially a script of their own, we begin the story of early chemistry in India from it. Pottery could be safely regarded as the earliest chemical activity in which materials were mixed, moulded and fired to achieve desirable qualities. Metal-working and other chemical practices such as brick-making, production of glass beads and using minerals for ornamental purpose come after that. These early settlements extended up to the Rajasthan desert. Pieces of pottery found here vary in shape, size and colour. They are chemically analysed to get an idea regarding the materials used and methods employed in making them. These analyses show that the prehistoric people knew the art of making pottery using burnt clay. Metal-ores were added to it to get the required colours, e.g., iron-ore for red and brown, copper-ore for blue and green and manganese ore for black and maroon shades. Earliest hand-made pottery is found in Uttar Pradesh, North Gujarat, Kashmir, West Bengal and Andhra Pradesh.

Coloured and wheel-made pottery is found at Harappa which was one of the centres of the Indus Valley Civilization. It was decorated with numerous designs including geometric and floral patterns as well as human and animal figures. Mica was a prominent ingredient which increased its strength and also provided protection against cracking. Wood or charcoal was used as fuel. Furnaces of various shapes were underground and were sometimes lined with bricks. The kiln atmosphere was varied from oxidizing in the case of iron ore for producing shades of red, to reducing for manganese ore for producing shades of grey and black.

Glazed pottery is found at Mohenjo-daro. It is the earliest occurrence of such pottery in the world. In the later part of the period, black and red pottery is found in Western India, in the region from Rajasthan to North Deccan.

Metals and Metal-working

Metal workers of pre-Harappan period only knew about copper, whereas, in Harappan period copper, lead, silver, gold and alloys such as bronze and electrum became known. Iron was not known in the Harappan age.

Copper was more often obtained from Khetri mines in Rajasthan than from Afghanistan. It was used in making a number of articles like vessels, implements and weapons. Bronze statues were also made. A copper-arsenic alloy was used in the place of low-grade bronze, since tin was in scarcity. Addition of tin or arsenic to copper, while casting prevents oxygen bubble formation since they act as deoxidizers. These alloys were probably

the results of using arsenical copper ores or those rich in tin. The bronze articles vary in their percentage of tin which is from 4.5 per cent to 13.20 per cent. A large number of them have tin about 10 per cent, which suggests that the addition of tin was deliberate to get bronze of required hardness. Because of the scarcity of tin ores in these parts, it is possible that it was imported from other places like Persia. Nickel is invariably present in these bronzes suggesting Khetri, Alwar, Singhbhum and Afghanistan ores as the sources of copper, since they are found to contain both arsenic and nickel. Lead is also present in a small percentage in copper and bronze. It renders the metal or alloy more fusible and hence more suitable for casting. Addition of lead appears to be unintentional though, possibly as an impurity. Hazaribag and Rajputana copper ores are rich in lead, and also those from Afghanistan and Baluchistan.

From the aforesaid account, it is apparent that metallurgy was quite advanced in this period. Harappans smelted almost pure copper from sulphide ores and made tin and arsenic alloys of copper. Thus hardening of copper using these elements was a known fact since pre-historic times. Metal-forging techniques such as field-working, annealing, running-on, revetting, cire-perdue-casting were also known to them. Harappan metal workers even had the earliest tubular metal drills and the true saw.

As to the problem whether copper-bronze technology of the Harappans was a direct import or a result of indigenous gradual development, the absence of any resemblance between the Harappan technology and West Asian metal technology on one hand and individualistic features of Harappan copper base material on the other, suggests some common basic technology on which the West Asian and Harappan grew independently. Both of them independently developed technologies to suit their individual ores. To support this suggestion there is a need to carry out extensive excavations in these areas.

Bricks: Bricks were manufactured on a large scale to be used in making houses, boundary walls, public baths, etc. They were remarkably uniform in size and were baked to improve their strength.

Glazed Pottery: Pottery of the kind known as Faience was produced here. Powdered mixture of soda, silica, lime, colouring agents like metallic oxides were mixed with oil to make a paste. After painting on an article, it was fired at high temperature to form a glaze on the surface. Apart from it, glazed beads were found at the Indus Valley Civilization sites. Seals and bangles were also made from the same material as that of glaze.

Cement: It is found that gypsum cement which was light grey in colour,

and which contained sand, clay, calcium carbonate, in traces with high percentage of 'lime' was used as a mortar in the construction of a well in Mohenjo-daro.

Minerals: A number of minerals were used by the Indus Valley people in a variety of useful products, e.g., Cerussite (the carbonate ore of lead) and cinnabar (mercuric sulphide) in cosmetics and medicinal preparations. Galena (lead sulphide) for making eye-paints, white lead (lead carbonate) Steatite was used for plasters, hair-washes, etc. The Harappans also knew the technique of dyeing cotton with madder roots.

Gold and Silver: The noble metals gold, silver and electrum; which is an alloy of gold and silver in an approximate proportion of 20 to 80 respectively; made their first appearance in Harappan culture. Gold was exclusively used in making ornaments. Silver, apart from ornament, was used in making vessels and seals.

Gold was probably an import from Mysore. Gold ornaments are found at Lothal, Rajodi, Tekkalakota, Kausambi, Nevasa, Nasik, Nagarjunakonda, etc. Apart from Kolar mines, those at Hutti in Raichur district (Mysore), Ramagiri area in Anantpur district and Wynaad area in Nilgiri district (in Tamil Nadu) were also the possible sources of gold according to some scholars.

Primary mineral ore of silver is not available in India. Silver objects are excavated from the Indus valley civilization sites. Copper hoards from Gangeria also yield some 102 pieces of silver plates. Some scholars consider mines of Afghanistan and Armenia as probable sources of silver in ancient India. Other scholars are of the opinion that silver might have been obtained either from electrum or from argentiferous galena from the Burmese source.

There is an evidence of alluvial gold-washing, in the fact that gold-dust was paid as a tribute to Darius. Rivers of Maharashtra, Bihar and Madhya Pradesh flow over such rocks and yield dust, rich in gold.

Gold from Kolar and Hutti is light in colour and is necessarily electrum. Gold from Harappan sites resembles it. Hence it is suggested that gold-mining at Kolar must have started as early as that.

Separation of Silver from Lead Ore or Galena

Galena is roasted to get lead containing silver. It also contains impurities of antimony, arsenic, copper and tin. Lead along with silver melts before the impurities do. On heating it is made to flow out. On cooling lead crystallizes out which is then separated using perforated ladles. This process separates

some 85 per cent of lead. The remaining lead is separated using cupellation process. These methods were probably carried out for the silver-lead separation. Literary evidence to that effect is found in Kauṭīliya *Arthaśāstra*, a fourth century BC text. Medieval Sanskrit alchemical texts like *Rasaratnasamuccaya*, *Dhāturatnamālā*, etc. mention this separation.

Production of Gold

Gold usually occurs in native state. Its higher density is made use of in its separation from other earthy matter and sand. After pulverizing the large pieces, water is added and the whole mass is agitated whereby lighter matter flows off and heavier gold particles settle at the bottom. Finally they are heated in a clay crucible over charcoal fire.

Separating Silver and Gold from their Alloy—Electrum

Silver was probably separated from gold by either of the two processes which were commonly adopted in ancient times. One is the salt process in which common-salt when heated with electrum converts silver into its chloride and leaves gold unchanged. The second process is converting silver into its sulphide, by heating with antimony sulphide. Silver sulphide or chloride is further cupelled for obtaining pure silver.

Harappan silver is found to be associated with lead, when chemical analysis is carried out. Hence the surmise that it was extracted from argentiferous galena ores. Silver plates obtained from the copper hoard sites contain 4 per cent of gold or more. Hence, it appears that it must have been separated from electrum.

Amalgamation Process for the Separation of Gold

Scholars like Munn and Mahadevan, found near the Wandalli and Honkunni gold-working sites, crucibles which were used in ancient gold-extraction. These crucibles when analysed, are found to have traces of mercury which suggests the use of amalgamation for the separation of gold.

The Vedic Period (1700 BC to 500 BC)

Indus valley civilization disintegrated slowly around 1700–1500 BC, under attacks of nomadic tribes of the North-West. After this event, no civilized settlement appeared till the advent of Aryans. The Aryans first settled in the regions inhabited by the former Indus valley people and later they migrated

to the fertile land on the banks of the river Ganges. This period is characterized by the fact that it has both archaeological and literary evidence to support the dates of its beginning and flourishing. The literary evidence is mainly provided by the sacred, religious texts of the Aryans, viz. the four vedas *Rgveda*, *Yajurveda*, *Sāmveda* and *Atharvaveda*, in the chronological order. *Rgveda*, the earliest of the vedas is supposed to be of the fifteenth to twelfth century BC. *Rgvedic* hymns give some idea regarding the culture of the Aryans.

Gold, silver, copper and bronze are mentioned in the *Rgveda*. Gold was used in ornaments whereas utilitarian objects were made from the others. *Rgveda* also mentions a metal 'Āyasa' which is recognized as iron by most of the scholars.

There are a number of aspects of *Rgvedic* material culture which depict one kind of chemical activity or the other. The fermented juice of plant Soma [*Sarcostemma viminalis* or *acidum* (Roxb) Voigt] Somarasa, was supposed to bestow divine powers and immortality, upon its administration. Apart from somarasa other alcoholic liquors like *Surā* (barley beer), *Madhu* (honey beer) are mentioned in the Vedas. Tanning of leather, dyeing of cotton was also practised in that age.

After the *Rgveda*, the other three vedas were composed between 100 BC to 700 BC. *Yajurveda* mentions two more metals viz. tin (*Trapu*) and lead (*Sisa*). *Atharvaveda* of which *Āyurveda* is a part is chiefly a medical text. Roots of alchemical ideas are noticed in the *Rasāyana* part which is one of the eight sections of *Āyurveda*. This point is further elaborated in the section on alchemy.

The Aryans made a particular kind of polished grey pottery known as P.G. Ware, which is dated as of 1000–800 BC by the radio-carbon dating. Other varieties of pottery, e.g., red or Northern black-polished i.e., N.B.P. Ware were also made by them. The major landmark of this period is the advent of iron. We will be dealing with it and other topics such as cosmetics, glass, liquors, etc., which originated in the Vedic and *Āyurvedic* period but developed significantly in the later post-vedic or Buddhist period, in detail in the second section on Chemical Arts and Crafts.

After Vedas come the classical texts like *Brāhmaṇas*, *Upaniṣads* and *Purāṇas*, which were written in the post-vedic or the Buddhist period (500 BC to AD 500). They also contain stray references to these chemical activities.

Kauṭīliya Arthaśāstra (KA) is a literary landmark of this period. It was written by the Prime Minister of the Maurya emperor Candragupta who reigned in the fourth century BC.

Viṣṇugupta by name, the prime minister was famous for his insight in

politics, administration and war-tactics, and was therefore called Cāṇakya or Kauṭilya. He wrote a treatise on political economy, viz. *Kauṭīliya Arthaśāstra*, which touches all the aspects of contemporary life. For this reason it is considered as an important historical record of the time.

In the chapter on 'On the working of mining and factory' KA deals largely with metals and metallurgy. It gives guidelines as to what a mining minister ought to know. The author states that the mining inspector should have the know-how of copper-ores, quick-silver, location of ores, how to distinguish them by their colour, weight or odour. Further he describes location and characteristic features of gold, silver, copper, lead, tin and iron ores; treatment of ores, etc. There are instructions for the coin-inspector for moulding copper coins to which some 25 per cent of iron, tin or lead is added.

Production of salt from the sea and collection of shells, diamonds, pearls, corals was a common practice, which is seen in the instructions given to the salt inspector. If salt was imported from other states one-sixth of the imported salt was to be given as a tax. Salt production without the permission of the ruler, was fined, as was adulteration. Further are noted the amount of taxes to be paid by the mine-explorers.

KA gives detailed sets of rules for the gold-inspector. Some seven varieties of gold are described. They are *Jambunada*, *Sātakumbha*, *Hāṭaka*, *Sṛṅgisuktija*, *Jātarūpa*, *Rasavidha* and *Ākarotgata*. Four kinds of silver described are *Tutthotgata*, *Gauḍika*, *Kāmbuja* and *Cakravāla*.

Successive additions of copper to gold to produce different colours of gold, testing a gold-piece using a touch-stone, a test for gold using the solution of cinnabar, yellow or green vitriol, and cow's urine; making blue, yellow, white, green, parrot green, and dove-coloured alloys of gold with lead, further a number of silver alloys with copper and gold are described in KA.

The text also contains an article on the goldsmith's business where the author states rules laid down for him, including wages. Various modes of embezzlements are also described to protect the owner of the precious metal, i.e., the employer of the goldsmith. In this way it demonstrates that the art of extraction and purification of metals, making gold-jewelry had reached great heights at the time of the writing of the KA.

Caraka and Suśruta Saṃhitā. These are the celebrated Āyurvedic treatises on medicine and surgery written by Caraka in the first century AD and Suśruta in the second century AD respectively. Chemical knowledge of the time especially that related to medicine is compiled in them.

Caraka Saṃhitā (CS) also mentions nine sources of spirituous liquor viz. cereals, fruits, roots, wood, flowers, stems, leaves, barks of plants and sugar

from various sugar-yielding canes. Using them some eighty-four kinds of alcoholic drinks were made. Caustic alkalies have a special mention in CS. They are distinguished into two categories, ones which could be used for internal administration and the second, the ones which are used in external applications.

Suṣruta Saṃhitā describes the preparation of the alkalies in detail. Burnt ashes of plants are used along with limestone in these preparations. There is an interesting statement regarding the neutralization of an acid with alkali in SS. The author explains how the sharp burning caustic property of the alkali disappears with the addition of the acidic extract of fermented rice. Caraka and Suṣruta knew about the tonic value of a number of minerals. They describe a method of roasting iron, to get its soluble salts which are used as a tonic. Suṣruta mentions arsenic compounds such as arsenic oxide and sulphide and recognizes them as poisons. It appears that mercury was not used in medicines, in this period.

Taxila

At this stage, once again we take up the course of scanning through archaeological evidence to construct the story of chemistry from Caraka-Suṣruta's time to the fifth century AD. It was the period of flourishing of the great monastery at Taxila, which was the largest seat of learning of the time.

A series of explorations are carried out at Taxila which lies in the North-West of India. Archaeological finds of Taxila represent life and achievement of a period between 500 BC to AD 500. Pottery pieces unearthed at this place do not differ much from those found at Mohenjo-daro and Harappa. They include oil and wine-flasks, water-jars, ink-pots and drinking cups. A curious find is a water condenser. It was possibly employed to get the essences of plant extracts. A portable crucible made of sandy clay as well as painted and glazed articles are among the findings of Taxila.

As to metals and metallurgical practices, it is observed that copper and bronze are used to a lesser extent pointing to the scarcity of copper and tin. A variety of iron articles including utensils, weapons, carpenter's and blacksmith's tools, horse-bridle, elephant's goads and agricultural implements are found at Taxila. Scissors and spade are found for the first time here. Glass beads of about 500 BC, chiefly made of soda-lime-silicate are found here.

It appears from this account that metal-working, iron-steel making, glass pottery, etc. had reached a highly developed stage by the end of the Āyurvedic period. A number of chemical arts and crafts also slowly pro-

gressed and reached excellence. They are taken up for discussion in the next section.

II

CHEMICAL ARTS AND CRAFTS

Chemical arts and crafts which originated in the early civilizations like the Indus valley, the Vedic and the Buddhist; were glass-making, pottery, jewelry-making, metal-working, dyeing of clothes, tanning of leather, etc. They flourished in the early medieval period, partly due to improved skills, innovations, contacts with foreign countries and their products. It was also partly due to suitable economic conditions in the established empires. A number of new chemicals were used and new methods were discovered. Through this expanded chemical activity the factual knowledge increased. The artisans came to know more and more about the materials they were handling, their properties and reactions with each other. They could now make a better choice of ingredients and processes which led to a variety of improved products. Out of the innumerable chemical activities of this period, following are the major ones which contributed to the development of medieval chemistry.

Glass

Glass is a fused solid mixture of a number of substances like sand, lime, alkali and metallic oxides. It is brittle and it lacks a crystalline structure. Glasses are of various kinds, transparent, opaque, coloured and colourless. Silica, lime and alkali-soda or potash give rise to transparent glass. Glass is used for decorative purposes, e.g., glass beads, bangles, etc. and also in making containers and seals. The earliest appearance of glass is noticed in Mesopotamia as early as 2600 BC. It was also made in Egypt a little later, around 2000 BC. It appears that glass became known in India much later. No glass objects are found at the Indus valley civilization sites, except for some glazed articles. It is an intriguing fact because glazing requires a technique similar to that of glass-making.

A powdered mixture similar to the one which produces glass on fusing, e.g., alkali, sand, chalk, colouring agent like metal oxide, to which an oil or gum is added is coated over the surface of the pottery or bead which is to be glazed. It is then heated in oven to dry. When fired at a high temperature, a glaze is produced. When it enters the body of the ceramic article, it is known as porcelain. At the sites of Mohenjo-daro and Harappa, a number of such articles are found, also at Maski in South India (1000–900 BC) and

Hastinapur, Taxila (2nd–6th BC). An ancient glass factory is noticed at Kopia in the Basti district of Uttar Pradesh. It is attributed to a period between the third century BC to the fifth century AD.

Glasses and glazes were coloured by the addition of colouring agents like metal oxides. Tin and antimony oxides give rise to opaque glass. Different metallic oxides used for producing specific colours are:

Red— Cu_2O , Cu red haematinum	Green— CuO
Black— $\text{MnO} + \text{FeO}$, $\text{FeO} + \text{CuO}$	Bluish green— $\text{CuO} + \text{Fe}_2\text{O}_3$
Orange (Opaque)— $\text{Cu}_2\text{O} + \text{SnO}$	Deep blue— CoO
Deep violet—High percentage of MnO	Amethyst— $\text{MnO} + \text{Fe}_2\text{O}_3$
Chocolate— $\text{Cu}_2\text{O}_3 + \text{Fe}_2\text{O}_3$	White— Sb_2O_3 , SnO_2
Greenish— FeO	Yellow— Fe_2O_3
Turquoise blue— CuO	Brown— $\text{FeO} + \text{MnO}$
Bluish violet— $\text{MnO} + \text{CuO}$	Bottle green— Fe_2O_3

These pigments are found at the ancient sites, in the form of tablets or capsules. The glass-makers also knew about decolouring glass objects by fusing the manganese content.

Literary sources like *Rāmāyaṇa*, *Bṛhatsaṃhitā*, *Kauṭīliya Arthaśāstra*, *Śukranītisāra*, etc. mention the use of glass. Similarly foreign authors like Pliny, Strabo, Periplus also refer to glass in ancient India. They indicate to a period of 800 BC to 500 BC as the beginning of glass manufacture in India. Chemical and microscopic examinations of the ancient glass objects are carried out, in order to find their composition and properties; and to study the development of glass-making in India. These studies reveal the following facts.

1. The absence of lead in most of the glass objects and total absence of barium distinguishes Indian glass from the Chinese which contains large amounts of the above material.
2. The art of glass-blowing is dated as back as the last decades of the first century BC; which is supported by three sea-green flasks found at Sircap. They were also annealed before blowing and hence are well-preserved. Annealing removes internal strain and checks devitrification. Glass tiles are recovered at Taxila, near Dharmarājikā Stūpa.

Some of the glass articles possess relief designs. Special glass beads

were made, one having a layer of gold-foil in it and another having a milliflori pattern where the core is blue and has multicoloured decorations around it.

The above facts suggest that glass-making was on a large scale and a high degree of perfection was reached in it in ancient India.

Since glazed objects were found at the Indus valley civilization sites and since glazing and glass-making involve essentially the same chemical process, it is possible that glass-making was known as early as that and further excavations might prove the fact.

Another astonishing fact regarding ancient glass is that the vermilion-coloured glass objects from Nasik resemble greatly in the chemical composition to the similar material from Mohenjo-daro. This fact supports the earlier suggestion regarding the knowledge of glass making of the Harappans.

Although there is evidence of glass-manufacture at Taxila, no glass-furnaces or factories are excavated so far. One possible site of glass-factory is Kopia in Basti district of Uttar Pradesh, where glass fragments and lumps of unworked glass are found in large quantities. Glass slag is found at Kolhapur, Nevasa, Paunar and Maheshwar.

Considering the high silica content of Taxila glass, 6 to 7 per cent of magnesia and lime, and 17.5 per cent of alkalies some scholars regard Indian glass distinct from that of Assyria, Egypt and Rome. They suggest an indigenous origin for ancient Indian glass.

Glass furnaces of late medieval period are found at Mysore. It is possible that similar furnaces were in use in the ancient times as well. A large, domed furnace had a round opening at the top and another opening for feeding fuel at the bottom.

There was a platform at the centre of the furnace where crucibles for melting glass were kept.

Earthen crucibles with molten glass stuck to it, are found at Kopia.

The Mughal period (AD 1526–1707) saw the flourishing of the art of glass-making in India. Spectacles of glass were used in the early sixteenth century AD. It is possible that the Portuguese introduced them to India. Manufacture of spectacles from quartz was in progress at Tanjore in the late eighteenth century. Modern glass industry, with high technical standards, came into being in the twentieth century AD.

Iron and Steel

On the face of the facts that India has the richest deposits of iron ore and also that iron and steel metallurgy had reached great heights during early medieval period; as evidenced in the production of Wootz steel from which the famous Damascus blades were made; one would expect an early advent

of iron in India. On the contrary, iron age seems to have appeared late here. Both archaeological and literary evidences suggest that iron became known only in the Vedic age to which a date of 1700 BC to 500 BC is commonly ascribed. The earliest literary source to mention iron is *Rgveda* which is the earliest of Vedas. It mentions a metal 'Āyasa' which probably referred to iron. In his very illuminating article M.N. Banerjee gives innumerable instances from *Rgveda* and concludes that in Vedic literature, *Hiranya* signifies gold; *Rajata*, silver and *Āyasa*, iron. Further a number of textual examples are quoted by him where claws of the king of Gods are compared with *Āyasa*, arrows are tipped with it, also Agni or the fire is said to have an edge of *Āyasa*. Thus it appears that *Āyasa* was supposed to be a very hard, tough, tenacious, malleable and ductile metal. *Karmāra* was the term used for iron-smiths. Quoting *Taittirīya Samhitā* and *Śatapatha Brāhmaṇa*, Banerjee states that metal *Āyasa* was purified using fire, bellows and hammer, i.e., by smelting in a furnace where an air-blast was provided and the product was hammered to get the pure metal. From the description of the properties of the metal and its method of separation Banerjee recognises *Āyasa* with iron.

It appears that the *Rgvedic* smith manufactured steel from magnetic iron oxide ore in an open hearth made from mud, using bellows after adding the dried medicinal plant *Cassia auriculata* Linn. At the time of fusing bird's wings were added for carburization. Finally, the fused mass was hammered to get steel.

The archaeological evidence agrees with the literary one. Pre-Harappan metal workers knew only copper whereas during Harappan civilization bronze, lead, silver and gold became known. Although iron ore was used to get red and brown pottery, the metal was not yet separated. At the sites of the settlements in the Gangetic and Yamuna plains, along with decorative painted grey ware, are found ceramic pottery and iron objects like arrowheads, nails, chisels etc., from Panjab, Madhya Pradesh, Rajasthan, Maharashtra and Bihar. In South India also iron objects of 1000 BC are found.

Excavations carried out at Taxila reveal settlements of a period between 500 BC to AD 500. Iron objects found at these sites vary from household utensils, arms and armour, horse-bridles, elephant-goats to carpenter's and agricultural tools. Miscellaneous articles such as needles, plummets and unwrought ingots are also found. Spade and scissors are found to be of the first century AD.

Though the beginning of iron age in India cannot be stated with certainty, some conclusions can be drawn from the archaeological data. Early excavations had pointed to an earlier date for iron in South India than the North. More recent excavations at the sites like Taxila, Kausambi,

Hastinapur supply evidence of the earlier appearance of iron in Ganga-Yamuna doab region than in the South. Considering iron slags and ore from Hastinapur dated 1100–800 BC and Kausambi in 885 to 815 BC, a date of the ninth century BC is considered as a possible beginning of iron age in India. From excavations in eastern U.P., Bihar and Central India it appears that iron-working must have begun around seventh century BC at these sites.

Knowledge of iron-working spread to Orissa and South India at around 400 BC to 200 BC in three phases. We see that the applications of iron and steel rapidly increased from spearheads and arrowheads to knives, sickles and finally to household utensils. Thus, starting from the eleventh century BC in Ganga-Yamuna doab, the knowledge of iron-making spread in all parts of the country by the second century BC.

Chemical and metallographic analyses of ancient slag deposits as well as the artifacts, give an idea regarding the nature of iron produced, the metallurgical operations employed and the kind of ore used. Low percentage of carbon in the product suggests that carburization must have occurred unintentionally, in most of the cases. On the contrary, higher carbon percentage to the order of 1.1 per cent, suggests intentional carburization in the reduction process using charcoal, of the oxide ores. If some of the slag contains large amounts of iron oxide, it is possibly due to the reoxidation of iron due to high CO_2 : CO ratio during the operation. The metal workers must have with practice slowly realised that excess of carbon retards the reoxidation and this realisation must have resulted into a better yield of pure iron. Melting point of iron which is 1540°C was probably not reached by the furnaces employed. Yet the temperature of 1100°C must have been reached which lets the slag to flow out with ease. It was further removed by the forging operation.

The late advent of iron in India is attributed firstly to the high temperatures needed for iron forging whereas relatively low temperatures are needed in copper-bronze metallurgy. Secondly, unless steel-making is known, iron had no advantages over copper. Bronze (90 per cent Cu, 10 per cent Sn) is much harder than wrought iron. Unavailability of iron articles from times earlier than the first millennium BC could be partly attributed to its corrosive nature and that the smiths found it convenient to collect scraps and remake articles from it than extracting new metal from the ore. Since very few iron artifacts have been scientifically studied no general conclusions could be drawn in this regard.

In the post-vedic period we find that the *Suśruta-Saṃhitā* describes a large number of surgical instruments possibly made of steel. The iron pillars of Delhi and Dhar of the fourth and seventh century AD respectively stand

testimony to the remarkable skills of the iron-smiths since these pillars have hardly rusted in the period over 1500 years.

High corrosion resistance of these pillars is attributed to its high phosphorus (0.144 per cent), low sulphur (0.006 per cent) content and the absence of manganese. It is also possible that a film of magnetic iron oxide (Fe_3O_4) formed on the surface of the pillar protects it from rusting. Specific treatments like successive heating and quenching, after applying a mixture of salts, produce this film. Such processes are described in some alchemical texts. The iron pillar at Delhi is over 24 ft in height and 16.4 inches in diameter at the bottom, the upper diameter is 12 inches and it weighs over 6 tons.

The tribals of Madhya Pradesh, Maharashtra and Bihar, use primitive methods to smelt the iron ore.

Wootz Steel

Although advent of iron was a late event compared to that of copper and bronze, its technology developed very fast.

Indian iron and also steel was famous for its quality, especially hardness and sharpness of the edges of weapons made using it. The earliest reference is of fifth century BC. Ktesias, one at the court of Persia, mentions two swords which were presented to him by the Persian King, and which were made of Indian steel. Again in the fourth century BC Alexander the Great was presented with hundred talents weight of steel by Pauras, an Indian King. *Periplus* states that Indian iron and steel were exported to Abyssinia in the first century AD. In later centuries also one comes across innumerable evidences of this kind.

The culmination of the steel-technology is seen in the famous Wootz steel of South India. It was produced there since the sixteenth century AD. It was consumed domestically and internationally on a large scale. It was a high carbon steel which was made in the ceramic crucibles made of clay and rice husk. Magnetic iron ore was reduced using wood and leaves of specific plants.

The crucibles were formed of a refractory 'red loam' mixed with large proportion of charred rice husk. Wood was that of *Cassia auriculata* and leaves those of *Asclepias gigantea* or *Convolvulus laurifolia*. Smelted iron was refined by repeated heatings and hammerings. The ingots were then cut into pieces of half a pound to two pounds in weight. They were packed in a crucible with one-tenth part by weight of the chopped, dried wood and the whole mass was covered with green leaves. The mouth of the crucible was

filled and luted with clay. Some 20 to 24 crucibles were kept in a furnace and heated in the blast for $2\frac{1}{2}$ hours. After cooling cakes of steel were obtained. They were again heated for several hours below their melting point in the current of hot air. This eliminated the excess of carbon. Later these cakes were hammered into short bars and sold locally in this form. In places like Jabalpur and Darjeeling also this kind of steel was made. It was used in the making of edged tools which were tempered by plunging them while hot into water. Fire was made of charcoal and bellows were used for blowing air in, which enabled the crucible reaction to attain a high temperature. After heating for twenty-four hours in the closed crucible, in a highly reducing atmosphere at about 1200°C , an ingot of white cast iron was obtained. The crucibles are described in the iatro-chemical texts. Wootz steel cakes were exported to Damascus for making the sword-blades, which were esteemed for their sharp edge and beautiful, waterflowing pattern on them. Wootz steel was chiefly exported from places like Mysore and Salem. The exact method of tempering which gave hardness and other qualities to the product is not known yet, although sophisticated scientific techniques are tried to unearth it, using the crucible remains from the historical sites. Archaeometallurgical field-work in North Telangana has identified 93 sites of iron-smelting based on rich magnetite and lateritic ores.

Brass

Brass is an alloy of copper and zinc. The zinc percentage in brass varies from 20 per cent to 40 per cent. Brasses containing about 20 per cent to 30 per cent zinc are golden in colour and take good polish. Brass is mentioned in *Kautiliya Arthaśāstra* under the name *Ārakūṭa*. Caraka mentions it as *Riti* signifying its method of preparation by melting copper with zinc or smelting with its ores. Excavations at the sites of ancient Buddhist stupas have unearthed brass articles. Brass was extensively used in ancient and medieval India for making utensils as well as images, idols and artillery. Brass articles dating back to the fourth century BC are found at Taxila. Brass articles containing less than 6–7 per cent Zinc are found at Atranjikhhera (1200–600 BC). During the late medieval period, guns were made of brass since it is harder than copper. A brass statue of Buddha was discovered at Fatehpur which has an inscription on it, suggesting it to be a work of the sixth century AD. Huan Tsang, a Chinese monk who visited India in the seventh century AD, wrote about a Vihārā or a large hall constructed of brass. It points out that large-scale smelting of copper and zinc ores to get brass, also its working were well known to the Indians by that time.

Tantrik texts like *Rasārṇava*, *Rasahṛdayatantra*, etc. mention brass and its synthesis by roasting calamine with copper. Earlier brass was undoubtedly made using copper and zinc ores like oxide, sulphide, carbonate or sulphate. No separate name for zinc was known that time. *Rasaka* (calamine) was known to give rise to a tin-like metal upon roasting with carbonaceous matter in a closed crucible. A verse to that effect is found in twelfth-century text *Rasārṇava*. Some of the brass articles containing large percentage of zinc suggest that they were probably made by melting the two metals in the required proportion. It is experimentally proved that cementation process for making brass does not yield brass with more than 28 per cent of zinc. A high zinc alloy (84 per cent) called Bidari was used for ornamentation over gold and silver-ware, at Bidar near Hyderabad.

Zinc

Although brass was known from the post-vedic times, zinc, as a separate metal became known much later.

There are several reasons why zinc appeared late on the scene. Zinc oxide which is the chief ore of zinc, cannot be reduced below 1000°C and zinc formed at this temperature is in the vapour state since the boiling point of zinc is 923°C . Hence special arrangements are necessary to collect and condense zinc vapours thus formed. At high temperatures zinc vapour gets reoxidised. For this reason a reducing atmosphere is to be maintained and a closed crucible is necessary.

Calamine which is zinc carbonate, the main ore of zinc, had names like *Rasaka* or *Kharpara* in Sanskrit. A process for purification of zinc is given in Tibetan texts which were translated from Sanskrit in eight-ninth century AD. Also *Rasārṇava*, a text of twelfth-century mentions process of extraction of zinc from calamine.

Although zinc was known to be a separate metal from Nāgārjuna's time, it did not bear a separate name but was referred to as a metal of the appearance of tin i.e. *kūtilasankāsam*. Later alchemical texts such as *Dhātumañjarī* and *Dhātūkrityā* which are the works of the thirteenth to fifteenth century AD, zinc bore a separate name. It was recognized as the metal which is responsible for making brass from copper and was given the names like *Yasada* or *Yasadāyaka* (one which confers success in alchemical operations), *Jasada* or *Jasta*.

Zinc was exported to Europe from China since about AD 1605. It was called 'Tutenag'. Its nature or process of extraction was not known to the Europeans at that time. It was also spelt in a number of curious ways as

'tooth and egg' metal or 'Tutenag'. The Portuguese name for zinc was 'Tutenague'. Also a white alloy of copper, zinc, nickel and iron was called by the same name, when it was exported from China to Europe in early nineteenth century.

'Tutenag' probably is the twisted form of the original word *tutthanāg* for zinc in south Indian languages, e.g., Tamil.

Tutthanag is formed by the combination of two words *tuttha* and *nāg*. *Tutthanāg* thereby means, it is kind of lead (*nāg*) derived from *tuttha* or calamine (zinc carbonate).

It is probable that zinc was introduced to China from India in the late medieval period along with its name *tutthanāg* or 'tutenag'. Later, zinc and its alloys were exported to Europe from China under the same name, after the Chinese learned the method of extraction of zinc from calamine from the Indians who had the knowledge of it for more than four or five previous centuries.

The literary evidence regarding the separation of zinc is supported by the archaeological excavations at Zawar in Rajasthan. A large number of broken retorts, ash and heaps of slag are found here, which are scattered over the area of a few square kilometers.

The ore mined at Zawar is principally zinc sulphide with small amount of Galena. The ore is argentiferous and probably productions of lead and silver were also carried out here.

Zawar mines near Udaipur are dated by radio-carbon dating as belonging to the fourth century BC. But a large-scale production of zinc was carried out since the thirteenth century AD, by the distillation method.

In the year 1980 extensive archaeological investigations were carried out at Zawar which led to the discovery of the apparatus used for the downward distillation of zinc as is described in the Sanskrit alchemical text *Rasaratnasamuccaya*. The furnace is divided into two chambers. The upper one is the furnace chamber for heating the retorts and below is the one for condensing zinc vapour. An arrangement of 36 retorts in the upside down position, is in the upper chamber with the funnel part opening in the other chamber. A perforated terracotta plate is in between, through which the retorts open in the lower chamber. A stick is inserted in the retort before charging and luting, in order to keep the charge in place and also provide a way for the zinc vapours to come out. The charge consisted of zinc ore, chiefly oxide, common salt, carbaceous matter made into balls. Sulphide or sulphate ore is to be roasted before smelting. When the furnace is heated zinc oxide is reduced to zinc in the vapour form. The reduction is continued till the blue flame of carbon monoxide changes to white that of zinc. (It is

interesting to note that a verse describing the colour change of the flame, signifying the completion of the reduction of zinc ore is come across in an alchemical text of the fourteenth century AD viz. *Rasaratnasamuccaya*). Zinc vapours get condensed in the lower chamber.

Recently, electron microscopic studies of the materials have been made to observe the vitrification textures. Also phase studies are made using electron diffraction and X-ray diffraction methods, to examine the nature of various complex compounds of zinc formed in the process, with the aim of recovering zinc from the medieval deposits of retort-residues.

Saltpetre and Gun-powder

Discovery of saltpetre, i.e., potassium nitrate and its chief application in the gun-powder mixture is a crucial point in the history of chemistry. Knowledge of this potent chemical decided the destiny of a number of rulers and their kingdoms. A variety of literary sources Sanskrit, Persian, Tamil, Chinese, etc. are found to refer to Indians knowledge of the above materials in different periods of time.

There are mentions of fire-arms in ancient Sanskrit texts such as *Rgveda*, *Atharvaveda*, *Kautiliya Arthaśāstra* and *Manusmṛti*.

It appears that fireworks were made by the sixth century AD and were used in celebrations. Dandi in the sixth century AD wrote in *Daśakumāracarita*, about a magic powder (*Yogacūrṇa*) made for this purpose.

A certain paragraph in a Chinese text *Shi-yao-er-ya* by Mei Biao refers to the visit of an Indian Buddhist monk to China in AD 664 and about his knowledge of saltpetre, its extraction and applications such as a flux in smelting and also in transmutation of metals. The above Indian monk also knew about the flame test for examining the samples of saltpetre.

Since there are no mentions of fire-arms or fire-powder in the Kāmaṇḍaki's polity (fifth-seventh century AD) or *Agnipurāṇa* (ninth century AD) they were probably not known at that time. From the above two sources along with the Chinese it appears that although saltpetre was known and extracted, its use as an ingredient in the gun-powder mixture was not known till the ninth century AD.

A verse from the Sanskrit alchemical text *Rasopaniṣad* (written around eleventh-twelfth century AD) narrates preparation of a gun-powder mixture. The author clearly states that what is prepared is a *sphotaka* or an explosive mixture. The verse is quoted here.

'Seven salts (sea-salt, rock-salt, black-salt, saline-salt, ammonium chloride, Romaka (?) and potassium nitrate) are heated with alkalies; wax

and sulphur are added to it when an explosive mixture is said to have formed.'

Here potassium nitrate, sulphur and carboneous matter from wax were enough to make an explosive mixture.

A Tamil text, *Bogar karpam*, which is supposed to be written around the twelfth century AD mentions Potassium nitrate under the name *Inangam* (one with a great strength). The Tamil texts also describe the preparation of fireworks using sulphur, charcoal, saltpetre, iron-powder, copper salts, mercury, cinnabar, arsenic, camphor, etc.

Vāsiṣṭha Dhanurveda (twelfth century AD) describes *Nārāca*, *Nālikā* and *Śataghna* which are two metallic arrows and a kind of cannon respectively. The author also advises to store large quantities of *Ranjaka* (gun-powder), and *Śataghna* for protecting the fort.

Śukranītisāra of *Śukrācārya* written in the sixteenth century AD mentions gun and gun-powder. It also, gives a recipe for a gun-powder mixture consisting of saltpetre, sulphur and charcoal in specific proportions. Following is the part of the text in translation.

The *Nālikā* is of two kinds, large and small, small ones are 45 inches long, have a stock of tough wood and a barrel of bamboo with a bore of three-fourth of an inch. . . . The small *Nālikās* are carried by infantry and cavalry. The larger *Nālikā* has no wooden stock, it is made of steel and other metals and is carried on wheels. The small shot for smaller arms is made of lead or other metals, and the balls (*golā*) for the larger are made of iron with or without a shot inside them. The gun-powder or *Agni-cūrṇa* is composed of 4 or 5 or 6 parts of *Suvarci lavāṇa* (saltpetre), one part of sulphur and one part of charcoal of plant *Arka* (*Calotropis gigantea* Linn), *Snuhi* (*Euphorbia Nivulla Buch-Ham*) and other trees burnt in a pit so as to exclude air. The ingredients are to be purified separately, ground to fine powder and then mixed. The mixture is next soaked in the sap of *Arka* and *Rasuna* (Garlic), dried in the sun and reduced to a coarse powder like granulated sugar. There are many kinds of *Agni-cūrṇa* known to the experts, and they are composed of varied proportions of charcoal, sulphur, salt petre, realgar, orpiment, calx of lead, cinnabar, iron filings, zinc dust, shell-lac, blue vitriol, resin of pines, etc. Some give out white light like that of the moon.

A sixteenth-century travelogue by John Mandelsco describes extraction of salt petre in Gujarat, from black soil. Trenches were made in the earth filled with black earth and water was added to it. Mixing was done usually by treading over it. When clear water was taken out from it, it was led into another trench where it was allowed to dry and grow thick. After boiling and removing the scum, the solution was poured in earthen pots where it thickened to give cakes of salt-petre.

Salt-petre was produced on a large scale in India in the seventeenth

century AD. It was exported to England. The Bohras of Gujarat were experts at its production and refining. The fact that there was a flourishing salt petre industry in India in the seventeenth century AD itself suggests that the use of salt-petre in gun-powder mixture must have been known to the Indians quite early and probably before Babar's time.

The Banjaras of interior Gujarat brought it to Ahmedabad for sale. In the seventeenth century, the English and the Dutch tried hard to buy salt-petre directly from the producers without the State's (Muslim ruler's or Marhattas') interference as regards to the source, quantity to be bought and restrictions on its applications.

The earliest mention of a gun-powder mixture in the world is in a Chinese text of ninth century AD. The Chinese used rockets against the Tartars in the thirteenth century AD and it was in the late fourteenth century AD that they were used in Europe. Some scholars like H.M. Eliot and Dr Oppert are of the opinion that the Arabs learnt about fire-arms from certain translated Sanskrit treatises, in the eleventh century AD, and then they improved upon it. There are also suggestions that the words for gun (*Banduq*) and cannon (*Top*) have their origin in Sanskrit words *Piṇḍaka* (for ball) and *Dhūpa* (the rocket).

Whether Indians knew about the gun-powder mixture as used in fire-arms, before the Muslims used it in the fifteenth century AD, or not is still a controversial point.

Words like *Tu fang* (musket), *Top* (cannon) were used in *Mufarrih-ul-Qutub*, a book compiled in India in the thirteenth century AD contradict the claim that it was Babar who first introduced the cannon in India. In fact Babar wrote that Bengali soldiers were skillful gunners. In the fourteenth century AD Muhammed Shah Bahmani I got 300 gun carriages as spoils from Raja of Vijayanagar.

From the aforesaid account, it appears that salt-petre was known, extracted and used in the fire works even in the vedic times. Guns and cannons were made by the eleventh century AD in India. The Arabs came to know about it through translated Sanskrit texts. The activity rapidly increased and a very large number of guns and cannons were made after the sixteenth century AD which was the period of wars and instability.

Paper

Paper was probably introduced from China to India through Tibet in the eleventh century AD. The western parts of India appear to have acquired the knowledge of paper-making from the Arabs who themselves learnt it from

the Chinese. Formerly *Tāla patra* and *Bhūrja patra* (palm-leaves and bark of Birch tree respectively) were the writing materials used by the Indians.

From I-tsing's accounts it appears that paper was known in India in the seventh century AD, although it was a rare commodity, probably imported from China.

In the initial stages, the process of paper-making was simple and more or less alike in all parts of the country. A pulp was made from cleansed rags, hemp, old sacks, fishing nets and jute. Lime and soda were added to it for whitening the pulp. A wire sieve was dipped into it. When lifted up, it brought a thin sheet of the material with it. It was removed, pressed and dried by hanging in the sun. It was polished using a pumice-stone, a piece of wood or a shell. Gum was added to the pulp to give it the required strength. Dried paper was glazed with rice-water to which alum was added.

Sialkot, Zafarabad, Murshidabad, Ahmedabad, Aurangabad, Mysore, etc. were the chief centres of paper-making in medieval India. Paper from Ahmedabad was very white and glossy. The city produced a surplus quantity of paper which was exported to far-off countries.

Cosmetics and Perfumes

A large number of references come across in Sanskrit literature, to cosmetics and perfumes. They are found either as complete treatises on the subject or entries in encyclopaedias like *Bṛhatsaṃhitā* of Varāhamihira (AD 500) or *Mānasollāsa* of Somadeva (AD 1120), *Agnipurāṇa* and others. Some scant references are found in novels, poetry, etc.

Treatises *Gandhasāstra* and *Gandhayukti* were discovered in the year 1944. Two more were discovered by P.K. Gode, later; one is *Gandhasāra* of Gangādhara and *Gandhāvada* of an unknown author, with the commentary in Marathi. Hence they probably are of late medieval period.

Cosmetics and perfume-making was chiefly practised with the purpose of worship, sale and sensual enjoyments. Pañcatantra mentions sale of perfumes, indicating it to be an age-old practice. It was customary to dilute these scents, which were called 'Attars' with pure sesame oil.

The Bower manuscript or *Navanītaka* was discovered by Dr A.F.R. Hoernle in the year 1980. It is supposed to be a work of the second century AD. It contains recipes of hair-dyes which include a number of plants like indigo and minerals like *Kāśisa* (ferrous sulphate), iron powder, black iron or steel, and acidic extract of sour rice gruel called *Śukta*. Myrobalans are used as fastening agents. Sesame oil is the medium in which the dye is made.

Gandhayukti is a section in the encyclopedic work *Bṛhatsaṃhitā* of Varāhamihira, written around 500 AD. *Gandhayukti*, though literally means 'combination of perfumes'; signifies 'Art and science of cosmetics and perfumery. It lists the following chemical processes which are involved in perfume making.

1. *Pakva* or *Pācana*—decocting.
2. *Tapta* or *Tāpana*—heating.
3. *Samyukta*—*Samyojana*—Mixing.
4. *Pradhūpa*—*Pradhūpana*—fumigating.
5. *Sikta*—*Siñcana*—Sprinkling.
6. *Bodha*, *Prabodha*, *Udbodha*—*Bodhana*, *Prabodhana* and *Udbodhana*—mixing of powders.
7. *Vedhana*—blending one liquid into another.

Gandhayukti gives recipes for making scents to be used in hair-bath, hair-oil and perfumes. Various combinations of nine aromatic ingredients totalling to 84, are given. The nine substances are:

1. *Rodhra*—*Lodhra*—*Symplocos paniculata* Walt.
2. *Uśira*—*Andropogon muricatus* Retz.
3. *Bignonia Chelonoides*.
4. *Aguru*—*Aquilaria agallocha* Roxb.
5. *Mustā*—*Cyperus rotundus* Linn.
6. *Vana*—*Vamśalocana*—.
7. *Priyangu*—*Aglaia roxburghiana* Miq.
8. *Pathyā*—*Terminalia Chebula* Retz.

Any three of the above substances are to be mixed with Sandal, *Turuska* (Bitumen), *sukti* (*Nakha*—a fragrant substance) and quarter of *śatapūṣpa* (*Pimpinella anisum* Linn) and is fumigated with *Kaṭuka* (*Picrorrhiza kurroa* Royde and Benth), asafoetida and jaggery. Thus, eighty-four different scents are made.

The author also gives recipes for mouth perfumes, bath-powders, incense and talcum powder. The incense is made of a combination of aromatic ingredients, an inflammable substance like lac and a binder like jaggery and honey. An interesting entry is that of talcum powder made by powdering the mixture of certain barks of plants, musk and camphor. It is called *Puṣṭavāsa*. The author also gives a method for making a hair-dye using iron-powder, acidic extract of rice gruel and a plant *Kodrava* (*Paspalum scrobiculatum* Linn). Paste of myrobalan is used as a dye-fastener.

Gode considers the degree of excellence and refinement of cosmetics

and perfumes, current at any period of civilization, to be an index of the cultural development of that period. He quotes Gangādhara's classification of aromatic ingredients from *Gandhasāra* as follows:

1. Leaves—Holy Basil leaves, etc.
2. Flowers—Saffron, *campaka* (*Michelia champaka* Linn) cloves, etc.
3. Fruits—Pepper, nutmeg, cardamom, etc.
4. Barks—Bark of camphor, clove trees, etc.
5. Woods—Sandal wood, fire wood.
6. Roots—Nutgrass (*Cyperus rotundus* Linn) and *Vāta* (*Pavonia odorata* Willd).
7. Plant exudations—Camphor.
8. Organic products—Honey, musk, lac, ghee, etc.

Buchanan (nineteenth century AD) gives details of the manufacture of rose-water. 'A large copper till which can hold 150–200 liters of water and has a flat head, fresh roses are put in it with water and a tube bent at right angles takes the water-vapours carrying rose essence to the recipient copper vessel which is placed in a wide-mouthed earthen vessel containing cold water which condenses the vapours thus forming rose water. Sandal wood oil is impregnated with essences collected in this manner from aromatic ingredients like Bel (*Jasminum sambac* W.), Agar wood (*Acquilaria agollacha* Roxb.), flower of *kevara* (*Pandanus odoratissimus* Linn) and the respective Attara or scent is made.

Soap

Ancient Indians used certain plants and their fruits, i.e. soap-nuts such as *Ritha* or *Ariṣṭa* (*Sapindus trifoliatu*s Linn), *Śikekāi* or *Saptala* (*Acacia concinna* DC) also called Bahuphena (one which produces much lather) for washing clothes. Also fruits like *Bela* or *Śrīphala* (*Aegle marmelosa* corr.) *Sarṣapa* (*Brassica campestris* Linn) were used to wash different kinds of clothes. Other substances used along with the above fruit-pulps or decoctions were ashes of plants, powdered salts like *Yavakṣāra*, *Sarjikākṣāra* (impure potassium and sodium carbonates respectively) *Uṣa* or saline earth; *Gomūtrakṣāra* or the salt obtained from cow's urine.

There are references to these soap-like substances called *phenaka*, from the second, third century AD, in the texts like *Manusmṛti*, etc. Throughout the first and a half of the second millennia AD, we find a number of literary evidences to the use of soap-nuts in India for washing a variety of garments.

The earliest reference to soap, i.e., *Sābaṇa*, is found in Guru Nanak's

prayers written in the late sixteenth century AD. The word *Sābun* appears to have originated from the Portuguese word of soap (*sabao*), Persian (*sābūn*), Arabic (*sabon*), Turkish (*sābun*) all seem to be close to the Portuguese word. All Indian languages such as Marathi (*sābaṇa*), Hindi (*sābun*) have similar words for soap. Hence it appears that soap was unknown in India before the arrival of the Portuguese in the late fifteenth century.

There is a possibility that the Bohras of Gujrat made soap of some kind in the thirteenth century AD. Similarly some Marathi poets also mentioned soap in their works in the thirteenth century AD. Thus, we may surmise that crude soap in the form of cakes, possibly made from the mixture of soap-nuts, plant ashes, lime, natron, etc. was made in India around the thirteenth century AD. Later, the introduction of more sophisticated soaps was by the Portuguese in the sixteenth century AD. Indians definitely made soaps in the eighteenth century AD in Gujarat. They used oil of Eranda (*Ricinus communis* linn), seeds of plant Mahua (*Madhuca indica*, J.F. Gmel) saline earth Uṣa, and impure carbonate of calcium called *Samudraphena* which is cuttle fish bone. These soaps were used for washing clothes.

Slowly scented, soft soaps used for bath were made. The earliest soap factories were at Calcutta, Kanpur, Meerat, Mathura, Jodhpur, Bombay and Bangalore.

Ink

Before paper was invented, *Bhurjapatra* and *Tālapatras* were used as writing materials in India. Ink used on the *Bhūrjapatra* for writing manuscripts was made of almond-charcoal and cow's urine. This ink was waterproof.

At Taxila, during the excavations, an ink-pot has been unearthed and it suggests that ink was known and used in India from the fourth century BC. The Kharosthi documents discovered at Khotan point to the fact that ink was definitely used in the first century AD. The Ajanta caves display some painted inscriptions which were written with coloured ink made from chalk, red lead and minium. India ink has been used by the Chinese, Japanese and the Indians for a very long time.

Mānasollāsa or *Abhilāsītārtha-cintāmaṇi* written by Somadeva in the twelfth century AD mentions lamp black used for making black colour or *kajjala*. *Haritāla*, i.e. vermilion was used to paint yellow, the letters or portions to be deleted from the manuscripts. Formulae for black, golden, silver and red ink are also available.

A thirteenth century AD Mahārashtrian saint Jñāneswar mentions *Masi* or *ink*. Recipe for ink is also come across in *Rasaratnākara* of Nityanātha; an early sixteenth century text. *Bhallātaka* or marking nuts were used by the

washermen to mark the clothes before washing. Ink made from marking nuts and myrobalans kept in water, in an iron-pot, was black and durable. This kind of waterproof ink was used in Malabar and other parts of the country as well.

Jaina manuscripts were written in the medieval period, they were written using a special ink prepared from roasted rice, lamp black, sugar, juice of plant *kesurte* (*Verbesina scandens*). This ink could be used for writing on paper. Acacia gum was sometimes added to it, to give the shine. Juice of embelic myrobalan, when placed in an iron pot, gave a dark solution containing dark-coloured iron compounds like the tannate. This solution was sometimes added to the above mentioned ink. It had its drawbacks since iron compounds were injurious to the texture of the paper. For writing on palm leaves the Jainas made an ink consisting of juice of *Kesurte* mixed with the decoction of whole-wheat flour. The ink formed was very lasting.

Buchanan in the nineteenth century had observed that ink in both liquid and solid form was made using lamp-black collected by burning linseed oil, gum of plant *Mimosa indica* and water; all rubbed in an iron mortar using a wooden pestle. An infusion of gall-nuts in water was added to it and further rubbed. Lastly the pestle was dried to get dry ink. A Maharashtrian saint, Rāmadāsa, of the seventeenth century AD, has also given, recipe for making ink from lamp black.

Tannins are a group of substances of plant origin. They are amorphous powders, soluble in hot water and ether. Their solutions are coloured dark blue-black or greenish by the addition of ferric salts. It appears that this fact became known to the Indians during late medieval period, possibly after the thirteenth century AD and they used these solutions in ink-making. When it was found that this ink was not suitable for paper-writing, they returned to the age-old method of using lamp black or charcoal.

These tannins react with proteins to form a voluminous precipitate. Therefore, they are used in removing the insoluble proteins from animal hides. What is left is leather. *Tanning of leather* is mentioned in *R̥gveda* composed around 1700 BC.

Tinning of Copper and Brass

Copper metal from copper and brass utensils form hazardous copper compounds when it comes in contact with acidic ingredients of food which are stored in these utensils. Therefore, these articles are coated with a thin layer of metal tin. This process is called 'Tinning', or 'Kalai' in a number of Indian languages.

Historical references to tinning are found in sixteenth-seventeenth century texts, e.g. *Ain-e-Akbari* (1590 AD), *Rājadharmakoṣa* (1676 AD), etc.

In this process, the utensils are heated on fire and the surface is cleansed using ammonium chloride and subsequent dipping in water. Tin metal, having a low melting point, when rubbed over the hot inner surface forms a thin metallic coating over it. Tavernier (seventeenth century AD) in his book 'Countries round Bay of Bengal' mentions the discovery of new rich mines of tin in India and further remarks that it was only used in this country to tin cooking pots, kettles and other copper utensils. From the above dates it appears that 'tinning' was introduced to India by the Muslims.

Dyeing and Calico-printing

The principal dye-producing materials were plants and their products, e.g. madder, turmeric, safflower, etc. Others were inorganic compounds like orpiment, some insects like lac, cochineal, kermes also produced dyes.

Excavations at Mohenjo-daro produced a purple coloured cotton which is supposed to have been dyed using madder (*Rubia cordifolia* Linn). It establishes the antiquity of dye-stuffs in India. There is an archaeological evidence of dyeing on an industrial scale in India since the third millennium BC).

A number of classical texts like the *Atharvaveda* (100 BC) mention dye-stuffs like *Mahārañjana* (Safflower), *Nili* (Indigo), *Manjistha* (madder), *Lodhra* (*symplocos rucemosa*) and *Haridrā* (turmeric).

In the medieval period alum was recognized as a colour-fixing agent or a mordant. It was widely used for that purpose. Later in the eighteenth-century iron mordant was used for blue, green and violet dyes; aluminium mordant for the fixation of red dye-stuffs. Juice of vegetables was taken out and it was boiled over fire. Every now and then it was tested to see whether the boiling was complete. Some of the colouring agents of plant origin are listed below along with the part of the plant from which they originate and their specific uses.

Dye		Part of plant	Uses
1. <i>Morinda tinctoria</i> <i>Roxb.</i> (Ach)	Red and yellow	Stem, root	Dyeing and printing
2. <i>Majetha</i> —madder or <i>Rubia cordifolia</i> Linn	Red	„	„
3. <i>Lac</i> — <i>Coccus lacca</i> it is a resinous incrustation formed on the bark of trees by lac insect	Red, scarlet	Bark	„

4. Indigo— <i>Nil</i> <i>Indigofera tinctoria</i> Linn	Blue	Leaves, flowers	Dyeing cotton
5. Myrobalan (<i>Hālila</i>) <i>Terminalia chebula</i> Linn	Yellow	Bark, rind of fruit	"
6. Pomegranate <i>Punica</i> <i>granatum</i> Linn	Greenish yellow	"	"
7. Loth <i>Symplocas</i> <i>racemosa</i>	Deep red crimson	Bark	Dyeing silk
8. Har Shingar <i>Nyctanthes arbortristis</i> Linn	Yellow	Orange coloured stalks	"
9. <i>Kachnar</i> , <i>Bauhinia</i> <i>variegata</i> Linn	Red, pink	Bark	Dyeing cotton
10. <i>Babul kakar</i> <i>Acacia arabica</i> Willd	Brown	Bark leaves	"
11. <i>Imli</i> (tamarind) <i>Tamarindus indica</i> Linn	Black dye by adding iron salts	Galls	Madder dyeing calico-printing
12. <i>Chakanda</i> <i>Cassia tora</i> Linn	Blue	Seeds	Dyeing cotton yarn

Dyes were extracted from inorganic substances by repeatedly dissolving in water and allowing it to settle. Clear solution was taken out. The process was repeated a number of times and finally the solution was smeared on a pot and evaporated to get the dry dye.

Metals and minerals were mixed with natron (*Svarjikā*) and lime (*cunā*). Then that paste was boiled with cow's urine and water. Scum, gathered at the top was removed till the solution became clear. Then it was filtered using a cloth. A container smeared with *kāca* salt was used to store this solution. It was then placed in another bigger earthen vessel and heated. The essence was then collected by distillation.

Some more substances having tinting capacity are plants *Kampillaka* (*Mallotus philippinensis*), *Pattanga* (*Cesalpinta sappan*), *Jatuka* (a species of *oldenlandia*). Those of animal origin are *Indragopa* (Cochineal). *Āyasa* (iron) *kāsisa* (Sulphate of iron), *tuttha* (sulphate of copper) and *añjana* (sulphate of antimony) are some metals and minerals used for tinting purpose.

Synthetic dyes were made by mid-nineteenth century. Synthetic Indigo totally uprooted the native Indigo-dye industry.

Calico-printing

Ancient towns of Lucknow and Kanauj had a flourishing calico-printing industry. In the early seventeenth century the painted clothes were exported to Holland and Portugal. Later Farrukhabad took over the industry and by eighteenth century AD it became the prominent centre of calico-printing.

Earlier, for calico-printing two techniques were used, hand painting and block printing. By the eighteenth century AD, block-printing almost entirely took over. Bleaching the cloth, making it ready for printing, application of dyes using block-printing, using resist paste and applying the ground colour and finally, washing the cloth were the successive operations involved in this process. Alum solution was used as a fastening agent in hand painting.

For bleaching, a white emulsion made by mixing 5 to 7 lbs of castor oil (or equal parts of castor and sesame oil), two ounces of native alkali, a small quantity of powdered sheep dung and water was used. Pieces of cloth were dipped in the solution, rubbed, wrung and then left on the ground for three to four days. The process was repeated till the cloth became very white. Finally they were washed with clean water.

After bleaching the solution of powdered myrobalan, *Terminalia ballerica*, flowers of *Griselea tomentosa* (Dhawai), root of *Nordo stachys* (Balchhar), coconut and root of *Hedychium spicatum* Ham. (Kapur Kachri) and root of *Cyperus pertinius* (Nāgarmotha) was made and cloth dipped in it. This solution prepared the cloth for painting or printing.

A black dye was made of ferrous sulphate 2 lbs, water 3 gallons, flowers of *Griselea tomentosa* 102, gum of *Anogeissus latifolia* Wal. (Dhaumar) 6 lbs, ghee 2 oz and wheat flour 1 oz.

After printing with the dye, a resist-paste made of shell-lime, soap, gum *Anogeissus latifolia* wall (Dhaumar) and gum *Acacia* dissolved in water, was applied over the print so that it remained unaffected by the ground colour. The ground colours used were:

1. *Bāsantī*: (Sulphur yellow) prepared from *Delphinium ajacis* Linn boiled in water or turmeric boiled in water and then mixed with curdled milk.
2. *Khaki*: Prepared from the solution of ground Babul pods in water.
3. *Pink or Light Pink*: Prepared from the solution of different strengths of madder in water.
4. *Sabz*: Prepared from pounded termeric mixed with pomegranate rind to which European grey and green aniline dye are added.
5. *Sky-blue*: Prepared from the blue dye used in printing borders and patterns.

6. *Dove-grey*: From European violet dye mixed with the madder solution.

7. *Yellow-green*: From a decoction of ground termeric pomegranate rind and European green aniline dye. After the application of ground colour the clothes were washed in running water to remove the resist paste.

Alcoholic Liquors

Somarasa, the fermented juice of plant *Soma*, mentioned in the Vedas, is probably the earliest literary evidence of alcoholic liquors in India. *Kautiliya Arthaśāstra* (fourth century BC), mentions manufacture of liquor and ferments, while stating the duties of the superintendent of liquor. He also enlists various liquors as follows, *Medaka*, *Prasanna*, *Āsava*, *Ariṣṭa*, *Maireya*, and *Madhu*. They were prepared from various substances like rice, wheat flour, sugar, honey, jaggery and grapes.

A ferment called *Kiṇva* was prepared from the paste of grains of *Māṣa* (*Phaseolus radiatus* Linn), rice and *Moraṭa* or *Ankoṭa* (*Alangium salviifolium* Linn), etc.

Powder of *Triphalā* (the three myrobalans), spices like long pepper, black pepper, cardamom were also added to the liquor to improve the flavour. They probably were the enzyme-sources also.

A decoction of uncooked juice of plants (or fruits or grains) mixed with spices and *Kiṇva* (?) and kept under the earth or in the heap of grains to ferment for specific duration of time was *Āsava*. That decoction which is prepared from cooked juices was called *Ariṣṭa*.

Caraka Saṁhitā also mentions nine sources for making alcoholic liquors. They are cereals, fruits, roots, wood, flowers, stems, leaves, barks of plants, and sugar-cane. Various *Āsavas* were made from them.

It appears that the Harappans also knew about the processes of distilling liquor, since an assembly of clay articles similar to the distillation apparatus has been reconstructed. Liquors were brewed in South India since ancient times. Some sixty Tamil names are found in Sangam literature which is dated back to the first few centuries of the Christian era. In the coastal regions liquor was made from Toddy or Palmyra palm (*Borassus flabellifer* Linn). The pots in which the juice was collected were smeared from inside with *Cunā* or slaked lime. This was to prevent excessive fermentation due to the hot climate.

Medieval alchemical texts also mention fermented liquors and their methods of preparation. In the fourth chapter of *Rasopaniṣad*, plants are classified into various categories e.g., *Mahāviṣas* or strong poisons, *Upaviṣas*

or weak poisons, *Raktvarga*—which produce red flowers or juices, *Āmlavarga*—having acidic extracts, *Bjavarga* are those seeds which are useful in alchemical operations. The last is *Surāvarga*, i.e., those from which alcoholic liquors are made. A list of thirteen plants is also supplied by the author.

Kuramula—*Ipomoea paniculata* R Br

Viśālu—

Kancukī—*Carrissa carandus* Linn

Halā—*Cesalpinia bonduce* Linn

Matsyākṣi—*Solanum nigrum* Linn

Karaṭi—Safflower

Vajri—*Euphorbia antiquorum* Linn

Ākhukarṇi—*Ipomoea reniformis* Choisy

Saputriṇi—

Rājakośātakī—*Luffa acutangula* Roxb

Muktā—*Jasminum sambac* Ait.

Muktamūli—*Raphanus sativas* Linn

Dravantikā—*Ricinus communis* Linn

Alcoholic liquors are classified into different categories depending upon their applications in alchemical operations.

Dāśanapāśanī Surā—used in tying operations.

Sarvacāraṇī Surā—used in mixing operations of all kinds.

Drāvaṇī Surā—used in dissolving substances.

Raṇjanī Surā—used in dyeing operations.

Rasabandhanī Surā—used in binding mercury.

Rasasampātani Surā—used in distillation of mercury.

A process of making spirit from rice is described by Ray, J.C. This method was adopted by brewers of Orissa in the late nineteenth century. The process is similar to the one described above in *Kauṭīliya Arthaśāstra*. A ferment called *Bākhar* is used here in the place of *kiṇva*. It is mixed thoroughly with cooked rice and kept for 24 hours. The mouldy vegetable composition *Bākhar* induces the temperature of rice to rise and the fungus grows on it. Again equal weight of fully softened rice is added to it. After adding large quantity of water to it the mixture is kept in the vats buried under the earth, for 8 to 10 days. When a gas starts bubbling from it, distillation is carried out and proof spirit is obtained.

A liquor was commonly made from flowers of plant *Mahuvā* (*Bassia latifolia*). They are rich in fermentable sugars and tribals living in hilly

regions still practise this method to manufacture cheap, illicit liquor. It is named as *Mādhvī*. Hamilton writes about it in the late eighteenth century.

There is a very curious and useful tree, called by the natives of Bahar and the neighbouring countries, the *Māhwah* or *Māwee*. Its Sanscrit name as *Madhūca* or *Madhudruma*. It is of the classification of the Polyandria monogynia, of Linnaeus. The corolla of flowers, after being dried are eaten by the natives raw, or dressed with their curries and when even simply boiled with rice, they afford strengthening and wholesome nourishment. They are indeed often applied to a less laudable purpose, for being fermented they yield, by distillation, a strong spirit which the people here sell so very cheap.

Suśruta-Saṃhitā uses the word *kohala* for alcoholic beverage made from powdered barley. It is similar to the Arabic word *al-kohala* and modern world alcohol. Use of curds was also well-known to the Indians. Use of fermented drinks made from grapes, although known since *Kautiliya Arthaśāstra*'s time, became popular after Indians came in contact with the Greeks. Under the British rule, the nobles and kings started drinking imported wines and it hampered the economy of Indian breweries.

Pharmaceutics

Indian chemistry largely developed in the alchemical and iatro-chemical period (1100–1800 AD) through pharmaceutics. Medicines were derived in the classical period chiefly from the plants. Yet there were a few ingredients originating from animals. Metals and minerals were also used in synthesizing medicines. Preparation of medicines involved, collection of the above ingredients, their purification, extracting essences, compounding by means of various processes like grinding, pasting/maceration, etc. Chemical processes like dissolution, distillation, sublimation, precipitation, combustion, dilution, decocting, etc. were carried out in these preparations. *Rasacikitsā* school relied more on mercurial preparations. Distillation of cinnabar to get mercury in its pure form was carried out as seen in *Rasaratnasamuccaya*. Juices of a number of plants were used for purifying mercury. It was solidified using plant juices, metals and sulphur. Gold was also used in a number of drugs. Mercuric sulphide, known as *Rasasindura* or *Makaradhwaja* was made by subliming a mixture of mercury, gold and sulphur in a covered crucible. Crystals of reddish brown mercury sulphide were thus obtained. In this way, through pharmaceutics the medieval Indian alchemists cum medical experts discovered a number of chemical metallurgical processes, apparatus as well as inorganic compounds, thus greatly enhancing the progress of medieval chemistry.

Ornaments of Gold and Silver

The art of making ornaments from gold and silver is very ancient. It was practised by the Indus valley people. Gold being glittering yellow in colour and chemically less reactive, was employed in making ornaments. Silver was also used for this purpose, due to its colour and softness. Gold ornaments from Lothal, Rajodi, Tekkalakota, Diamabad and Kausambi are reported, as also from Adichanallur in South India, Nevasa, Nasik, in Maharashtra. They are from the early historic periods. South India reports making of gold ornaments from very ancient times (2000 BC).

Vedic literature mentions ornaments made of gold and silver. Addition of copper to gold, to make it harder and more workable is mentioned in *Kautiliya Arthaśāstra*. It appears that embezzlements were also not unknown in this period since Kautiliya cautions the employer in this respect.

Making of ornaments, soldering, using an alloy of zinc, brightening them, again recovery of gold from the solutions used in brightening; all involved a number of chemicals and processes. The goldsmiths were well aware of all of them. During the process of giving a particular shape to the ornament, or during soldering, the pieces are heated. Due to the small percentage of copper in gold, they get darkened. Copper gets converted to cupric oxide which is removed by dipping the article in a concentrated tamarind decoction. Thus the article becomes bright yellow but the soldered part remains white. It is then dipped in a mixture containing nitre, common salt and alum. The dissolved gold particles then get deposited on the solder surface forming a layer of shining gold on it. Sometimes ornaments were tinged red or violet by adding sulphur to the cleansing solution.

The cleansing solution, in the end, contained some proportion of dissolved gold. To recover it the solution was evaporated to get a solid residue. It was mixed with borax and cow-dung. A mixture of partially oxidized lead, copper and zinc was added to it and it was strongly heated in the hearth. Lead got removed as litharge and an alloy of gold-silver-copper was left behind. The individual metals were separated using various parting methods.

Small-scale Non-ferrous Metal Industries

Bronzes, which are copper-tin alloys, when contain more than 20 per cent tin are known as high-tin bronzes, bell-metal or speculum metal. They were traditionally employed in making mirrors, musical instruments like the gong, the cymbal and the cell; and kitchen-wares. These bronzes are found

to acquire properties like hardness, and stiffness on slow cooling. Similarly sonority is produced by quenching them at a particular temperature. Due to their high tin content, chances of food-poisoning are reduced. In Kerala these articles are being made for over three hundred years. Aranmula metal mirrors, Kadavallur eating bowls and gongs are famous. This points to the knowledge of high-tin bronze processing of the Kerala artisans.

Mirzapur has been famous for its brass and bronze industry. Artisans of Mirzapur, called *Niyaras*, collect scrap, dross, slag, i.e., all the rejects from non-ferrous metal industry and produce standard brass, bronze and copper-nickel ingots by refining in fire. They use a variety of furnaces to produce specific products like German silver, brass and bronze.

Several places in India, e.g., Bastar district of Madhya Pradesh; Midnapore, Dankura and Burdwan districts of West Bengal produce artifacts using metal-casting methods, viz. open cast, part or closed moulds or the lost-wax or investment casting process.

Sulphates of Copper and Iron, i.e. Blue and Green Vitriol Respectively

Copper sulphate has been known in India since very ancient times. Due to its turquoise-blue colour it was named in Sanskrit as *Mayūra-greeva-Tuttha*, 'i.e. 'of the colour of a peacock's neck'. It had synonyms like *Tuttha*, *Tutthaka* or *Sasyaka*. It was synthesized from the copper mines of Rajputana, Khetri and Singhana, by roasting copper pyrites and dissolving the mass in water. Next the solution was evaporated to obtain crystals of copper sulphate. It was known to be a salt of copper, for *Bhāvaṇṇaprakāśa* written about 1500 AD, says that it contains some copper and therefore possesses some properties of that metal. It is described in this work as astringent, emetic, caustic and useful in eye-diseases, skin-diseases, poisoning, etc. The purification was carried out by rubbing with honey and clarified butter and heating in a crucible. It was then mixed with whey for three days and dried. Pure copper sulphate thus obtained was then used for internal administration.

Sulphate of iron, copperas or ferrous sulphate had a name '*Harātuttha* or *Kāsisa*' or 'green sulphate in Sanskrit. It occurs as green crystals soluble in water. Naturally, iron pyrites get oxidised to iron sulphate. Natural green copperas is found in many parts of India along with alum shales. It is synthesized from iron pyrites. Moistened iron pyrite is exposed to atmosphere to form its sulphate, a solution of which, upon evaporation and crystallization, yields iron sulphate. It is largely employed in the dyeing industry as a colour producer and a mordant.

Alum

Alum which is *Saurāṣṭraja* in Sanskrit, is mentioned in *Suśruta Saṃhitā*. It has synonyms like *Kaṃkṣi*, *Tubarī* or *Saurāṣṭri*, which are given in Amarakoṣa, a seventh-century synonymous dictionary. As the name signifies it is abundant in the soil of Saurāṣṭra or modern Surat. At this place and also at Sahabad in Bihar state, it is manufactured from early historic to the modern times. Alum shales are dug out and exposed to atmosphere for four months. Then they are spread in large pan-like squares and moistened with water, when after 10–12 days crusts are formed which are called *phitkari ka beej* or 'seeds of alum'. They are then boiled in large iron vessels lined with lime, along with saltpetre which is obtained by lixiviation of village refuse. (Nitrates from the refuse with potassium carbonate give saltpetre in solution and carbonates precipitate out). Alum seeds, i.e. sulphates of copper and iron, when mixed with saltpetre in the proportion of 15:6, give double sulphate or alum on crystallization. Alum was chiefly used as a mordant in dye industry. It was also used in āyurvedic medicines.

III

 HISTORY OF ALCHEMY (AD 800–1300) AND
 IATRO-CHEMISTRY (AD 1300–1600)

In India alchemy flourished in the medieval period. Like in the other world civilizations it, too, had two characteristic features, viz. gold-making and elixir-syntheses. The two faces of alchemical practice, the metallurgical and the physio-religious, were superimposed to give a single picture, where mercury and its elixirs were used in the so-called transmutation of base metals into noble ones as well as for internal administration, for purifying the body, rejuvenating it and taking it to an imperishable and immortal state.

The ideas of rejuvenation, longevity and immortality which became the basis of physiological alchemy can be traced to earlier historical sources. The belief that the liquid extract of 'Soma' plant was potent and was drunk by Gods for achieving immortality, we come across in Vedic literature. Other alchemical notions such as that of gold being the purest and the noblest of all metals and that it can confer its imperishability upon others by mere contact, are also very ancient. This notion explains the use of gold and its compounds in medicinal recipes. Buddhist literature of fifth-sixth century AD also gives recipes for synthesizing medicines from substances of plant and mineral origin which would give great strength, long life and immortality.

As to metallurgical alchemy, one finds references to brass-making and making other kinds of gold-like alloys in Kauṭilya's *Arthaśāstra*. The name for brass was *Āraṇṇa*. The same text tells us how to make alloys from metals like gold, silver, lead, iron, copper, etc. of a desirable colour. Use of mercury in making gold-coloured amalgams was also known in Kauṭilya's time, as seen in one of the verses from the same text.

'The different kinds of golds are *Jāmbūnadham*, *Śātakumbham*, *Hāṭakam*, *Vainavam*, *Śṛṅgiśūktijam*, *Jātarūpam*, *Rasaviddham*, *Ākarotgalaṃ* and *Suvarṇam*.'

Here *rasaviddham*, i.e. 'the one obtained from the treatment with mercury' is also included as a 'kind of gold'. The inclusion of 'Hāṭakam' in the above list also gives an evidence of alchemical practice, since *Haṭaka*'s are the elixirs made from mercury and other ingredients and they could transmute other metals into gold (i.e., gold-like metals).

The Philosophy of Mercury

We come across the evidences of alchemical practice, in the true sense of the word, in the texts written in the medieval period. These texts primarily dealt with gold-making and elixir syntheses. Elixir or *Rasāyana* was a substance which could transform other base metals into gold and silver, as well as confer longevity and immortality when taken internally. In fact, gold-making was looked upon as a test which is to be performed prior to administering the elixir. If an elixir proved successful in transmutation of metals it was supposed to be safe for internal administration.

The alchemist looked upon transmuting metals as purifying them, as bringing them to an imperishable state, that of gold. This process was looked upon as identical to that of culturing human body and making it indestructible. That these two processes were supposed to be parallel is evident from the following verse of *Rasaratnākara* of Nāgārjuna.

'I shall certainly tell you whatever is asked by you, i.e. remedies of warding off wrinkles and grey hair, and also stop ageing. These preparations can act with equal efficacy on the metals as well as on the human body.'

Owing to its heavy weight, silvery white and shiny appearance and fluidity and also to its property of readily combining with other substances; mercury was regarded as the most potent of all substances and of possessing divine properties. This fact is evident from various names given to mercury such as *Mahārāsa*—chief of all *rasas*, i.e. substances or chemicals. *Raśendra*—Indra (or king of Gods) of the *rasas*.

Other names for mercury were *Pārada* (the one which leads us to cross the ocean of life), *Sūta* (born—in the sense originating from God), *Haribīja*

(essence of God Śiva), *Svarṇakāraka* (gold-maker), the last one suggesting its alchemical applications. The portions containing mercury were supposed to give longevity and immortality, thus making it the chief ingredient of the powders used in transmutations and as elixirs.

Mercury had to undergo eighteen processes before it could be used for transforming either metals or human body. These processes are specified in *Rasāyana* texts. They are:

1. *Svedana*—Steaming or heating using water bath.
2. *Mardana*—Grinding.
3. *Mūrchana*—Swooning or making mercury lose its form.
4. *Uttāpāna*—Revival of form.
5. *Pālana*—Sublimation or distillation.
6. *Rodhana*—Potentiation.
7. *Niyamana*—Restraining.
8. *Sandīpana*—Stimulation or kindling.
9. *Gaganabhakṣaṇa*—Consumption of 'essence' of mica.
10. *Cāraṇa*—Amalgamation.
11. *Garbhadruṭi*—Liquefaction—internal.
12. *Bāhyadruti*—Liquefaction—external
13. *Jāraṇa*—Calcination.
14. *Rañjana*—Dyeing.
15. *Sāraṇa*—Blending or preparation for transformation.
16. *Sankramaṇa*—Acquiring power of transformation or penetration.
17. *Vedhana*—Transmutation.
18. *Sevana*—Becoming fit for internal use.

A religio-philosophic base was given to mercury based alchemy in India. Mercury was looked upon as the essence of God Śiva and sulphur as that of Goddess Pārvati. Sometimes mica was also named after Goddess Pārvati, viz. Gauri, since Gauri is another name of the same Goddess and means 'a fair one'. A number of texts like *Rasārṇava* were written as a dialogue between Śiva and Pārvati, where Śiva confers the alchemical knowledge upon Pārvati. A combination of male and female principles, i.e. mercury and sulphur (forming cinnabar or mercuric sulphide) or mercury and mica, was supposed to be potent and was thereby consumed as *Rasāyana* or a medicine for increasing body fluids or vitality.

In Buddhist alchemical texts also we find a parallel concept.

Prajñāpāramita (one with countless or boundless intelligence or wisdom), a name for Buddha; confers alchemical knowledge to his disciples. Considering the popular humanitarian image of Buddha, it is no surprise that he fitted well as a conferrer of knowledge of making elixirs which have healing and rejuvenating properties. In fact, some of the minerals which were part of these elixirs did have tonic effect on human body.

Āyurveda and Rasāyana

The earliest mention of *Rasāyana* was in *Āyurveda* which was probably composed by eighth-ninth century BC, since it is a part of *Atharvaveda*, the last of the four Vedas. Vedas were supposed to be written between the fifteenth to the eighth century BC. *Āyurvedic* system is a very ancient tradition of Indian medicine. Caraka, the renowned medical practitioner of the first century AD, tells us that original *Āyurveda* consisted of eight parts and *Rasāyana* was one of them. The eight parts were:

1. *Kāyācikitsā*—Therapeutics.
2. *Śālākya*—The science of special diseases of the eyes, nose, ears, mouth, throat, etc.
3. *Śalyapaharṭṛka*—Surgery
4. *Viśāgara vairodhikaprasāmana*—toxicology
5. *Bhūtavidyā*—Psychiatric knowledge
6. *Rasāyana*—Rejuvenation
7. *Kumārbhṛtya*—Pediatrics
8. *Vājikaraṇa*—Knowledge for increasing virility.

We find the earlier *Āyurvedic* treatises such as *Caraka-Saṃhitā*, an extensive use of plants and plant products in the synthesis of medicines. Metals like gold, silver, lead, copper, iron and tin were used in medicinal preparations. Minerals like iron pyrite, copper pyrite, bitumen, salts such as common salt, alkaline salts, black salt, fossil salts etc. were known to have medicinal properties. Certain compounds like orpiment, realgar, iron and copper sulphates, antimony sulphide etc. were usually used in external applications. A combination of metals, such as *Sarvaloha* (which includes tin, lead, iron, copper and silver), as a finely divided powder in Myrobalan juice was known as a tonic. Sulphur was used in medicines, applied externally for skin diseases and also for internal administration in the form of a suspension in plant juices, for asthma, cough and chronic skin diseases. Bronze

was used in making apparatus. Various salts, earths, alum, sulphur, quartz etc. had internal as well as external applications.

It is interesting to note that mercury is not mentioned in *Caraka Saṃhitā*, nor cinnabar which is mercuric sulphide. Though 'Sindura', i.e. mercuric sulphide or sometimes lead oxide, was known from ancient times, its use in elixir-preparation was not known. Thus, it appears, that mercurial medicine was a later development in the history of Indian medicine.

Mercury was included in texts such as *Dhanvantari Nigānthu* or *Rājñigānthu*. *Rasāyana* in earlier texts probably did not include mercury. *Rasāyana*, in the sense of 'medicines, derived from mercury' appeared in the medieval period during which a large number of alchemical texts were written.

The Hindu Philosophy cultivates transcendental tendencies which influenced Indians for over two millennia in India. Yet, every now and then, we find the elements of materialism coming up in the form of *Vṛātyas*, as they were called. After the decline of Buddhism and before Śāṅkarācārya reinforced the Hindu Philosophy, materialistic tendencies came to the fore in the form of Tantrism. Hence the period between 800 AD and 1300 AD is called Tantrik period in the Indian History. Tantras offered to give the divine experience in this very life. It advocated that preservation of body or *Kāyā-Sādhana* was the essential part in attaining this goal. Here mercurial preparations assumed great importance, and alchemy was at its peak during this period. A number of Tantrik texts such as *Kubjikātantra*, *Rasaratnākara* were written which contained alchemy along with characteristic features of Tantrism.

Tantrism developed as a counter-philosophy to the idealistic 'Vedānta' philosophy, just like Taoism developed as a counter-philosophy to Confucianism in China. Parallels between Tantrism and Taoism, and relation of Tantrism to science are discussed by D.P. Chattopadhyaya in his work *Lokāyata*, where he aptly writes,

The concept of physical immortality and its connection with the alchemy of Tantrikas is, again, strongly reminiscent of ancient Taoism. The Taoists, as Needham showed, were emphasizing the importance of certain techniques like the respiratory technique (*Prāṇāyāma*), the gymnastic technique (*āsana*), the sexual technique (*Rasāyana*)—and all these for the purpose of attaining a state of material immortality. This conception of material immortality, he added, was of incalculable importance to science because it stimulated the development of the technique of alchemy. We have seen that precisely the same thing was said of Tantrism by our Tantrikas themselves, unlike the followers of the idealistic system of Indian philosophy who belittle the

importance of the body and dream of the Liberation of the soul. The Tantrikas with their supreme emphasis on the material human body (*Dehavāda*) conceived liberation only in terms of the development and the culture of the body (*kāyā-sādhana*). It is no wonder, therefore, that they should have been so much concerned with concrete material measures that could ensure the development and the preservation of the body itself. This explains their contribution to alchemy and medicine. In short, the proto-materialism of the Tantrikas was the clue to their proto-scientific tendencies.

Alchemical Texts of the Medieval Period

Numerous alchemical texts were written between the ninth and the fourteenth century AD. They contain a combination of metallurgical, proto-chemical as well as iatro-chemical knowledge.

Some texts, e.g. the tantrik texts are such that the alchemical ideas form only a part of them and some other texts are such that they are wholly devoted to alchemy. Texts like *Māṭṛkābheda tantra*, *Rasārṇavakaḷpa*, *Rasakaḷpa*, etc. fall in the first category. Those coming under the second category are the following:

- Rasaḥṛdayatantra* by Govind Bhagwatpād
- Rasaratnākara* by Siddha Nityanātha
- Rasārṇava* by an unknown author
- Rasendracūḍāmaṇi* by Somadeva
- Rasaratnasamuccaya* by Vāgbhaṭa
- Rasaṅkārakāśasudhākara* by Yasodhara
- Rasarājalakṣmi* by Rāmeṣwara Bhaṭṭa
- Rasendracintāmaṇi* by Dhunḍukanātha
- Rasendracintāmaṇi* by Ramcandra Guha
- Rasasāra* by Govinda Ācārya
- Rasakaumudi* by Sarvajñacandra
- Rasabheṣajakaḷpa* by Surya Paṇḍita.
- Rasasaṃketakālikā* by Cāmuṇḍa
- Lohaṇḍaḍḍhaṭi* by Sureṣvara
- Kankāligrantha* by Nasirshah (Hindi)
- Rasamuktāvali* by Devanātha.

A number of alchemical texts were also written in the Tamil language. They are known as Muppu texts. These texts were written by practitioners of the Siddha system of medicine. The more prominent Siddhas were

Agastyār, Bogār, Rāmdevār, Karuvurār etc. Alchemy, with both its characteristics, metallurgical as well as physiological, is clearly reflected in these texts.

There were alchemical texts written in other Indian languages as well e.g. Hindi, Telugu, Kannada, Marathi, Bengali, Oriya etc. The followers of Jaina sect also wrote such texts which are found in Western India. They are essentially similar to the other texts in their alchemical content. Thus, it may be concluded that alchemy was much in vogue in India during the medieval period and people of all languages and sects participated in it.

Endeavours of the Medieval Alchemist

As we read the alchemical texts written in the medieval period, we come to realise the colossal nature of the alchemist's activities. He used the earlier knowledge of metals, minerals and that of the plant kingdom to design his methods, and also developed upon it from his experience. Since in his methods, the purity of the ingredients was of utmost importance, the alchemists adopted various methods of purification. The substances frequently used in the alchemical operations were metals like gold, silver, iron, lead, copper, zinc, tin and mercury. Arsenic and sulphur were also used. Orpiment—arsenous sulphide As_2S_3 , realgar—arsenic sulphide As_2S_2 and cinnabar—mercuric sulphide Hg_2S_2 were of great value. Other compounds which largely occur in such operations are:

Iron or copper sulphate	$FeSO_4$	$7H_2O$
	$CuSO_4$	$7H_2O$
Iron, silver or copper pyrites	Metallic sulphides	
Sodium carbonate and chloride	Na_2CO_3 ,	$NaCl$
Ammonium chloride or Salt ammoniac	NH_4Cl	
Potassium nitrate or Salt petre	KNO_3	
Borax	$Na_2B_4O_7$	$10H_2O$
Calamine or zinc carbonate	$ZnCO_3$	
Lead oxide—minium, red lead	Pb_3O_4 ,	PbO

Different kinds of gems and mica occur in a number of recipes. Animal derivatives such as milk, ghee, wax, liquor, dung, honey, meat, urine and blood also found their use in alchemical methods.

The transmutation processes, designed by the alchemists were based on a few principal chemical operations such as making gold or silver coloured

Nāgārjuna in Tibetan in the seventeenth century AD, in which he writes that Nāgārjuna was born and brought up in a Brahmin family of South India and was afterwards converted to Buddhism; also that he was a celebrated alchemist.

Kumārajīva, a Central Asian monk, translated *Life of Bodhisattva Nāgārjuna* into Chinese, as early as AD 401 to 409, which is included in the Chinese version of Buddhist *Tripiṭaka*.

Considering P.C. Ray's discussions on Mahāyānism, Tantrism and alchemy, in the light of the Nāgārjuna's treatises translated into Chinese, it seems plausible that the Mahāyānist patriarch Bodhisattva Nāgārjuna was an authority on medicine and alchemy.

Rasaratnākara of Nāgārjuna is a smaller text than the later alchemical texts. A large part of this text is devoted to metallurgical operations such as extraction and purification of ores and metals. It is interesting to note that calamine i.e. zinc carbonate, which is the chief ore of the metal zinc, was known in Nāgārjuna's time and it was used for the extraction of zinc and also in brass-making. This is seen in the following verses of *Rasaratnākara*.

Rasaka or calamine is digested repeatedly with fermented paddy-water, natron, clarified butter and mixed with wool, lac, *Terminalia chebula* and borax, and roasted in a covered crucible when it yields an essence of the appearance of tin.

What wonder is that calamine . . . roasted thrice with copper converts the latter into gold?

Brass was not, however, recognized as an alloy but was termed as *Kāñcana* or gold. It should be noted that zinc was not known in Europe till thirteenth–fourteenth century AD. Portuguese merchants who visited India in the tenth century AD reported having seen a metal resembling tin in appearance, and which was called *cālin* or *cālaem* and that Indians made a lot of money by selling it.

Zinc was exported to Europe from China in the seventeenth century and at that time the Europeans did not know what it was. Zinc was separated for the first time in England in the year AD 1680.

Nāgārjuna, on the other hand, termed zinc as *kūṭīlasamkāsam*, i.e. the metal resembling tin. This means that he knew that it was not tin but a different metal. In the later centuries, zinc adopted new names such as *Jasada*, *Jasadāyaka* or *Yaśada* clearly indicating to its application in brass-making. (*Yaśada*—convener of success, probably in alchemical operations).

The alchemical texts written in fourteenth–fifteenth centuries viz. *Dhātukriyā* or *Dhātumañjari* give synonyms of zinc as *Jasada*, *Yaśadāyaka*, *Rupyabhrātru* (brother of silver), *Charmaka*, *Kharpara*, *rasaka* etc. Nāgārjuna's

name for calamine was *Rasaka* but he gave no separate name for its essence, i.e. zinc. This fact indicates to the antiquity of zinc in India and also supports the belief that *Rasaratnākara* was written before zinc was recognized as a different metal and separate names were given to it.

The verse in which an amalgam of mercury and gold is used for making an elixir, marks the shift of Indian alchemy from elixirs of plant origin to that of mercury. The above method is similar to the one adopted by Chinese alchemists in the second century AD. It is also similar to the method of preparing elixirs or *Senthuram* in Tamil alchemical texts.

In the final few verses the author of *Rasaratnākara* gives names of apparatus used in alchemical processes such as *Śilāyaṅtram*, *Pāsāṇayaṅtram*, *Bhūdharaṅtram* etc. in all, twenty-six yantras or pieces of apparatus. He also quotes the names of earlier alchemists such as Sākaṇḍa, Māṇḍavya, Vaśiṣṭha etc. indicating to the fact that alchemy was at its advanced state in Nāgārjuna's time.

Rasārṇava

After *Rasaratnākara* of Nāgārjuna, there appeared a number of alchemical treatises in the eleventh-twelfth century viz. *Rasahrdaya*, *Rasārṇava*, *Rasārṇavakalpa*, *Rasaparakāśasudhākara*, *Raseṇdracintāmaṇi* etc. Among them *Rasopaniṣad* and *Rasārṇava* are the largest consisting of about 2600 verses. The author of *Rasārṇava* appears to be a Hindu of 'Śaiva' cult. This text is written more systematically than *Rasaratnākara* of Nāgārjuna. It is subdivided into eighteen chapters.

The first chapter introduces the philosophy of mercury and gives various rituals to be performed by the practitioner. The second chapter deals with the selection and initiation of disciples. The third and the fourth chapters describe apparatus as well as the characteristic flames of a number of substances. The author also gives the particulars regarding various kinds of fires (sources of heat) to be employed in the numerous chemical operations.

The fifth chapter introduces the reader to the medicinal plants, salts, acids, bases etc. From the sixth to the ninth chapter an account of all the metals, minerals along with their methods of extraction, purification and dissolution in respective solvents is given. The next, tenth chapter is devoted to mercury, its fixation, physical states and cultivation operations performed on mercury. The particular operation by virtue of which mercury loses its volatile nature and becomes more reactive is termed as fixation or 'killing'.

The author gives a detailed description of methods of fixing mercury, using other metals, salts and plant products in the chapters from eleventh to fifteenth. *Rasārṇava*'s chapters sixteenth, seventeenth and eighteenth are important from 'alchemy' point of view. Transmutation of metals is described in the sixteenth and seventeenth chapters whereas the eighteenth deals with physiological alchemy or elixir-making.

Rasārṇava is the first text of its kind in Indian alchemy, in which alchemy is discussed fully and exhaustively. The later texts with a few exceptions, which used this format were by no means as exhaustive. Other authors were in the habit of quoting from *Rasārṇava*, either a verse or two or several verses as seen in *Rasārṇavakalpa* text.

Considering the above facts it seems that *Rasārṇava* was the most prominent and widely read text on alchemy in the centuries after the twelfth.

Rasārṇavakalpa

Very few of the *Rasāyana* texts have been translated into English. B.V. Subbarayappa and Mira Roy have edited and translated the text *Rasārṇavakalpa*. It is part of a Tantrik text *Rūdrayamala*. *Rasārṇavakalpa* is probably a compilation of earlier texts made around eleventh century AD. A part of this text is also found in *Rasārṇava* text (verses 78 to 207 of *Rasārṇavakalpa* are found in *Rasārṇava*). Some other sections are also common to both, e.g. *Viṣodakakalpa*, *Caṇdrodakakalpa* and *Śailodakakalpa* (i.e. sections on the poisonous water, moon-water and mountain-water respectively) with slight changes in their content. Some forty plants are mentioned in this text.

Fundamentally, *Rasārṇavakalpa* is a text on transmutation of base metals into gold and silver. A few methods of elixir-syntheses are also given in this text. This text is arranged in a number of sections, and named according to the particular plant which is used in the methods given in that section, rather than the metallurgical operation involved in it. e.g.

1. *Aparājitakalpa* is a section on *Clitoria ternatea*.
2. *Brahmaṇḍīkalpa* is a section on *Lamprachaenium microcephalum*.
3. *Aśvagaṇḍhākalpa* is a section on *Withania somnifera*.

We find that the number of plants mentioned in the text *Rasārṇavakalpa* is less than that of *Rasārṇava* text. Certain substances of animal origin such as goat's blood, pig's fat, earthworm excreta are not seen in *Rasārṇavakalpa* which are found in the other text. Transmutation as well as elixir syntheses of *Rasārṇavakalpa* are simpler with fewer ingredients, as compared to

Rasārṇava text. Certain poisonous substances such as copper sulphate, ammonium chloride, borax are excluded from the edible-elixirs of *Rasārṇavakalpa*. These facts suggest that *Rasārṇavakalpa* is a later text as compared to *Rasārṇava*.

Rasopaniṣad

Rasopaniṣad is one of the largest Sanskrit treatises written on alchemy during the medieval period. It contains over two thousand and five hundred verses in its eighteen chapters. It is probably a part of a larger treatise *Mahodadhi* which is no more extant. It was written around eleventh-twelfth century AD, in South India. Like other Sanskrit alchemical texts written around 100 AD, *Rasopaniṣad* chiefly deals with the so-called transmutation of metals and to a small extent with the experiments of physical immortality. The language is Āyurvedic in nature but it does not contain any āyurvedic recipes as seen in later texts like *Rasaratnasamuccaya*. This text has been translated into English.

Rasopaniṣad stands apart from other alchemical texts like *Rasārṇava*, in the sense it does not provide primary information on the subject, e.g. description of apparatus or eighteen *Samśkāras* (method of cultivation) of mercury etc. The author is more interested in alchemical experimentation and he divides the chapters according to the chief chemical substance or reaction discussed in it. *Rasopaniṣad* was written as a record of alchemical experiments than as an exhaustive book dealing with all the theoretical and experimental aspects of alchemy.

Plants, their various parts and products such as juice, gum, etc. form an inevitable part of alchemy of *Rasopaniṣad*. Study of plant and their applications in this treatise, gives an idea how extensively they were employed and how far the science of botany was developed at the time of writing of this text. Properties of plants such as their acidic or alkaline extracts, other chemical constituents of their various parts such as dyes, or carbon content of its wood, are responsible for their numerous applications in alchemy.

Rasopaniṣad, in all its eighteen chapters together, describe an amazing number and variety of alchemical golds and silvers. It discloses the enormous nature of activity which the author has painstakingly elucidated. Alloys are made by either melting together two or more base metals or by diluting the noble metal with a baser one. Golden and silver-coloured amalgams were also made. A critical study of the text discloses the author's knowledge of metals and metallurgy. A whole chapter is devoted to gold-silver-making

processes using tin as the starting material. It suggests that some important facts about tin were known to the alchemists, e.g. there are two physical modifications in which tin exists, white and grey, tin has a low melting point, or that pure crystalline tin resembles silver and addition of little silver to pure tin inhibits the transformation of white tin to grey tin etc.

The twelfth chapter is devoted to cleansing metal surfaces and removing tarnishes from copper and brass. These are considered as necessary operations to be carried out before electroplating and enamelling in modern metallurgy. Medieval Indian alchemists also employed such methods, to obtain clean, lustrous metals before they were melted together to get homogeneous alloys.

The author of *Rasopaniṣad* employs a variety of crucibles in the alchemical and chemical operations he is engaged in. From the choice of crucibles he makes, it is obvious that he had the basic knowledge of their construction and characteristic applications. Not only that he could construct a number of different crucibles suited for a particular chemical operation or a particular reaction mixture, he also lined them with various pastes to serve some specific functions, e.g. to supply acidic, basic or reducing atmospheres, to provide a non-absorbent coating etc.

Rasaratnasamuccaya of Vāgbhaṭa

Rasaratnasamuccaya written by Vāgbhaṭa in the fourteenth century AD marks the beginning of the iatro-chemical period of Indian chemistry. This is a Buddhist text since the prayers are addressed to the principal of physicians (*Bhaiṣajyaguru*), i.e. Buddha; in the opening chapter. As in the other alchemical treatises like *Rasāṇava*, the substances are first divided into various categories, which forms the chapters from the second to the eighth. The succeeding chapters give the details of apparatus, chemicals such as acids, bases, oils, earths (ores), poisons and solvents.

The eleventh chapter of *Rasaratnasamuccaya* is devoted to purification, fixation, incineration of mercury. The rest of the text is devoted to numerous medicinal preparations which are prescribed in the treatment of diseases and also for rejuvenation. A remarkable fact noticed is that elixirs of longevity and immortality as well as transmutation of metals are totally absent in this text.

During the iatro-chemical period a number of *Rasāyanas* were made using metals, non-metals and plant products. Tonic value of several minerals was recognized. When these substances were water insoluble, their soluble compounds were made. Also colloidal solutions were made of sparingly

soluble compounds. Thus the main aim was to bring the metals and non-metals into a solution form. The process was called *Dṛti* (melting or dissolution) or absorption into body of these dissolved material was called stabilization or *Sthirikaraṇa*. *Bhasmīkaraṇa* or 'making a calx' was also discovered for a number of substances. Experiments were performed to find the drug with better therapeutic properties. Thus in the iatro-chemical period, i.e. after the thirteenth century AD research was directed towards finding more efficacious drugs in solution or calx form. Mercury was often used along with above substances, when it was found to enhance the therapeutic value of the drug. Collecting the volatile essence 'Arka' of the drug was a development of this period. Drugs like Opium, Akkalkarā, khurāsani, Ajawain, Jamālgotā, Jāyaphala, Mājuphala, Gulāb, Bhāṅg, are found only after the fourteenth century AD. These words could, therefore, be used as keys to determine the date of writing of a text.

In this way, a large number of treatises, totally devoted to medicine were written in the later centuries. Ancient works by Caraka, Suśruta and Vāgbhaṭa (e.g. *Aṣṭāṅghṛdaya*, *Aṣṭāṅgahṛdaya Saṃgraha*) were still referred to. A number of compendia in which extracts from different texts were compiled together, were written in the centuries between the fifteenth to the seventeenth, e.g. *Raśendrasārasaṃgraha*.

In the later part of the iatro-chemical period also a great many number of texts were written. They are characterised by the mention of calomel or *chobichini* (China root or smilax China) for treatment of *Firangaroga* or syphilis. They also mention a number of mineral acids and their mixtures under names like *Śaṅkhadrāvaka* or *Dāhajala* (solvent for conch shell and burning water respectively). *Rasamañjari* of Salinatha, *Rasarañjana*, *Gandhakakalpa* are of this period.

Rasapradīpa is one of the standard works of the late iatrochemical period. It mentions calomel and chobchini as a remedy over syphilis. It is generally accepted that Chinese traders in Goa made this drug known to the Portuguese in about AD 1533. Hence it is surmised that *Rasapradīpa* is a product of the late sixteenth century. Another characteristic feature of this work is that it gives a recipe for producing mineral acids by sulphur. With this recipe, *Rasapradīpa* is undoubtedly a land mark in the history of Indian chemistry. *Svarṇatantra*, another text of this period describes a mixture of mineral acids which the author names as *Śaṅkhadrāvaka*.

Here, an account of a few texts has been given in order to get an idea regarding their nature. From their contents it should be possible to assess the contribution of Indian alchemy to chemistry in general.

Mercury was known and was used in the extraction of gold by amalgamation or in amalgamation gilding since ancient times, but extensive study of mercury and its compounds and the processes of purification or killing of mercury, was made by the alchemists. Metallurgical operations carried out with an aim of gold-making enabled the alchemist to accumulate new chemical data. Alloys with varying percentage compositions were synthesized. Variations in physical properties, due to variation in the percentage composition, were observed by them. Control of temperature was vital in these pyrotechniques. It was achieved by using different furnaces and fuels.

Again, there were chance discoveries, such as the knowledge of the flame test for identification of ore; also the knowledge of volatile, sublime or explosive nature of certain substances.

Discovery of mineral acids can be safely regarded as the greatest contribution of alchemy to chemistry. The waters with names like the 'mountain water', 'poisonous water' and 'moon water' of the Sanskrit texts were actually mineral acids. The alchemists discovered them during their experimentation. They were found to have a number of applications in alchemical operations. These acids served the purposes of dissolving metals, cleansing metal-surfaces, fixation of mercury or providing an acidic medium for carrying out certain reactions. These mineral acids were stored in the hollow of a dried gourd since they could not be stored in metallic containers because of their corrosive action on them. Physical and chemical properties of these acids are described in a number of verses in the texts like *Rasārṇava* and *Rasārṇavakalpa*.

The verse in *Rasaratnasamuccaya* which gives the preparation of 'essence of alum' or sulphuric acid is given below:

Tuvari or alum is purified when immersed in *kanjika* (or the fermented rice water or crude vinegar) for three days. It (alum) when rubbed with *Kṣārāmla* (acidic salt) and heated, certainly gives its essence.

Here *kṣārāmla* or acidic salt is ferrous sulphate or *kāśīśa* which along with alum, on heating gives sulphuric acid. Hence the earlier belief that mineral acids were not known in India until the sixteenth century AD could be incorrect. This point is of great relevance since the early chemical industries of Europe were based on syntheses and applications of mineral acids, thus giving impetus to the industrial revolution of European countries.

The older attempts at transmutation of base-metals into gold were proved to be baseless by the modern atomic theory. Still the enterprises of the medieval alchemist, though never yielded what they were looking for,

helped to accumulate considerable data which when studied devoid of its superstitious and religious content, disclosed basic facts, which with meticulous experimentation led to the correct ideas about the nature of elements, properties of matter, and theories of chemical combination and later to the modern atomic theory, bringing the chemical revolution of the eighteenth and nineteenth century to a successful end.

Great many alchemical and iatro-chemical texts remain unexplored in a large number of oriental collections. Most of them are in manuscript form. Only when all these are explored and their contents made known, that one will be able to judge the true nature of activity, and the development in theoretical, factual knowledge through it. A detailed study of a few of them have brought to light some interesting facts which are mentioned above. Critical studies of selected treatises and archaeo-chemical analyses of the finds of further explorations will no doubt give the true picture.

Thus, with the decline of *Rasaśāstra* school (of alchemy) there appeared a school of *Rasacikitsā* in which a fruitful combination of Āyurvedic and *Rasāyana* medicines is seen.

From the aforesaid account of Indian alchemy, it is clear that it was fundamentally similar to alchemy practised all over the medieval world, with its idea of gold-making and elixir of life, originating from the philosophy of mercury. Still, it had its own special features. The philosophy of Śiva and Gauri being the originators of alchemy, mercury and sulphur being their essences, extensive use of plants inherited from Āyurvedic practice and finally a fruitful union of Āyurvedic medicines with that of mercury form the chief characteristics of Indian alchemy and iatro-chemistry of medieval period.

For the lack of literary tradition it is not possible to exactly pin-point the origin of alchemy or to know the factors responsible for the transition of medicines prepared from plants to the mercurial ones. The Buddhists played a key-role in this transition. Either they were responsible for originating the mercury-based alchemy through their love for medicine and relief of the poor and the sick; or for the introduction of mercurial medicines into India from China, during their long intercourse with it, between the second and tenth century AD.

In India, the three practices of metallurgy, alchemy and medicine were interlinked and inter-dependent. Alchemy developed considerably in medieval period, when it borrowed from the former metallurgical, botanical and medical knowledge. Also with its new experience alchemy further expanded their boundaries.

Transmission of Scientific Ideas between India and Neighbouring Culture Areas

India had contacts with its neighbouring countries from times immemorial. Glazed steatite seals of the Harappan type are found in Ur and other cities, cylinder seals engraved with elephants which resemble the Indus style are recovered from Eshnunna. This archaeological evidence suggests that India had relations with Western Asia in the third millennium BC. It has been said that modern western civilization is indebted to Sumerians. Prehistoric contacts between India and Sumer suggest Indian contribution from the earliest times.

There was a flourishing Indo-Roman trade in the first century BC. Sugar, pepper, indigo, cardamom, precious stones etc. were exported from South India. Mineral and metal products were also exported. Apart from commerce and trade, there ensued a transmission of philosophical as well as scientific-technological idea between India and its neighbours. The advanced knowledge of Indian scholars in various disciplines like mathematics, astronomy, medicine etc. impressed the rulers of neighbouring countries to such an extent that the activity of translating important treatises relating to the above mentioned areas of knowledge and experience gained roots. It occurred specially in the case of Persia and China, though it was well-known among the Arabs and Greeks alike. Indian medical knowledge was held in high esteem. Indian plant products were used in various prescriptions by the Greek authorities.

In his *De medicina*, Celsus describes lithotomy, a surgical operation developed and practised by the Hindus and described in *Suṣruta Saṃhitā*.

Arabs knew about Āyurveda and Indian medicine in the ninth century AD. Calif Hārūn ar-Rashīd (AD 786–809) was cured of a chronic illness by an Indian physician called Manka, who was specially invited to Baghdad for the purpose. Several Āyurvedic works were translated into Arabic by the order of the ruler at this time. Court physicians wrote about the Indian system of medicine, and the names of Indian physicians who visited Baghdad were also noted down.

One such court physician of ninth century AD, Ali Ibn Rabban at Tabarī wrote *Firdaws al Hikmah* (Paradise of Wisdom) in which he wrote a summary of Indian medicine in its seventh part. He used *Caraka Saṃhitā*, *Suṣruta Saṃhitā*, *Mādhavanidāna* and *Aṣṭāṅgahṛdaya* as sources, to write his account. He categorically stated that he included Indian system in his work since it was excellent.

Different Sanskrit manuscripts in libraries of the world also provide lists of Sanskrit works which were translated into Persian from 1000 to 1800 AD. These lists contain works on Hindu sciences, e.g. Astronomy, mathematics, cosmology, medicine, magic and occult sciences. It might have included some works on alchemy as well. It is worthwhile to note that the renowned physician Jabir bin Hayyan lived during this period.

In the year AD 771 Indian cultural mission reached Baghdad and presented a copy of *Brahma Siddhānta* to caliph Al Mansur who ordered the court astronomer Al-Fazari to translate it into Arabic. *Brahma Siddhānta* exercised a lasting influence on the Muslim sciences of stars. Mirza M.Y. quotes Arabic sources and state that these influences took the form of a definite school of astronomy called as *As-Sindhind* (*Siddhānta*). Various Sanskrit works were translated into Arabic once the movement started. It will be interesting to trace Indian scientific heritage in the works of Muslim scientists and philosophers of the period.

India and China also had contacts with each other since ancient times. After Buddhism was introduced to China in the early centuries of the Christian era, exchange of philosophical as well as scientific ideas followed. Hundreds of texts on philosophical as well as secular subjects were translated by the Buddhists into Chinese. Numerous Chinese texts written during the Tang dynasty (AD 618–916) refer to Indian scholars and their knowledge of science.

One of the earliest reference is found in the bibliography of Sui dynasty. It gives a list of Indian scientific books translated into Chinese. Some medical works attributed to Nāgārjuna are still extant in a medieval collection of works. They are on topics ranging from perfume-making, printing to ophthalmology.

A certain paragraph in a Chinese text *Shih Yao Erh Ya* by Mei Piao refers to the visit of a Buddhist monk to China in AD 664 and about his knowledge of salt-petre, its extraction and applications. The above Indian Buddhist monk also knew about the flame test for examining salt petre, as seen earlier.

Further, one more episode quoted from the text *Yu Yang Isang Tsu* describes how knowledge regarding mineral acids was transmitted to China through a brahmin scholar, who was brought to the Chinese court along with an Indian prince—prisoner of seventh century AD.

The above instances go a long way to ascertain the transmission of Indian sciences and techniques to neighbouring culture areas during medieval period.

All the above translated texts Arabic—Persian and Chinese present

themselves as excellent source material for tracing scientific development of medieval India.

IV

THE PRE-MODERN PERIOD (AD 1600–1900)

During the period AD 1300–1600 chemistry developed chiefly in the form of alchemy and iatro-chemistry. Chemical arts and crafts continued to flourish. From early seventeenth-century onwards a marked decline in alchemical writings is observed. Alchemy which was zealously practised from the beginning of the Tantrik period, lost its flavour. It was possibly on account of the realization that it could not deliver the goods it promised viz. synthesis of noble metals. Extensive experimentation over a millennia proved it beyond doubt that it was not possible to synthesize gold and silver by means of the pyrotechniques adopted by alchemy.

It was a period of ascendancy for iatro-chemistry. More and more mercurial medicines were incorporated in the traditional system and many of them proved efficacious as in the case of calomel. The new works of this period were commentaries of the old treatises, their translations into regional languages with explanatory notes; or compilation of selected verses relating to a particular topic, from various standard texts. Dictionaries and encyclopaedia were also made. Some of the texts which were basically āyurvedic in nature contained some chapters on mercury and other metals. Some references to alchemy are also noticed in these texts.

Dravyaguṇaśataślokī of Trimalla Bhaṭṭa, a seventeenth century text is a work on āyurvedic materia medica with its last section devoted to metals and mercury. One text named *Rasarājakaḥśmī* has explanatory notes in Marāṭhi. Another work of early eighteenth century viz. *Śivatatvaratnākara* of Keladi Basavaraja is an elaborate encyclopaedic work on metals, minerals, their uses and effects when combined with other substances. This work also gives various methods of conversion of base metals into gold. Moreover it describes a chemical laboratory and the proper arrangement of articles in it. This is a new feature for such texts. *Āyurvedapraśāsa* is yet another similar work by Mādhava Upādhyāya. It was composed in the beginning of the eighteenth century AD. It appears that the author was an expert of āyurveda as well as alchemy.

After the decline of alchemy, iatro-chemistry probably reached a steady state for the next 150 to 200 years and then it too declined due to the introduction and later acceptance of western medicine in the twentieth century. During the period of stagnation āyurveda continued to answer the

medical needs of the Indian people, without significant progress or incorporation of new ideas or drugs. The pharmaceutical industry based on āyurveda also continued to exist on a low key and it slowly declined.

The chemical arts and crafts which served the people over two millennia, e.g. pottery, brick-making, glass and ceramics, ornament-making etc. continued to flourish during this period. The story was different for some of the arts though, which were for the first time encountering competition from the superior and cheaper products of the industrialised nations. They were chiefly the industries like dyeing, iron and steel etc. Some of the industries just didn't take off, e.g. that of manufacture of mineral acids. Although mineral acids were separated in the sixteenth century AD, as witnessed in the later alchemical texts, they had no applications, more so with the decline of native small-scale industries. There was a large time-gap between the giving up of old methods of production of certain chemicals, e.g. alkalies and acidic extracts, and the adoption of newer methods based on the knowledge of modern chemical ideas. After the old ones became obsolete it took about 100 to 150 years for Indians to learn and adopt new techniques and it was a time when foreign products poured in. Thus indigenous units using traditional techniques generally declined, more as a result of adverse policies of the rulers rather than decline in the demand. Manufacturing power of India was being slowly crushed and people fell back more and more on agriculture.

Geography, geology and surveying were the first sciences to be introduced by the British to India because they were interested in having accurate knowledge of geography and natural resources of the conquered territory. Similarly, railways in India was a result of declining market of Europe and the United States to the British iron and steel. Necessity to speed up the transport of raw materials such as iron ore to the ports, was no less responsible for it. Manufactured iron and steel products from Britain found an assured market in growing demands of Indian railways, which the indigenous small-scale industry could not fulfil.

Indian dye industry met with a similar fate. It survived till mid-nineteenth century. Indian dyes were of superior quality and low-priced and they brought considerable returns to the European trading companies. Indigo plantation was, therefore, supported by the East India Company till the beginning of the nineteenth century. The first magenta dye was prepared by AD 1856 and was imported by a Bombay firm. Next was synthetic Alizarin dye to be introduced to the Indian market.

Around 1880 Indigo was cultivated by some 1,11,000 acres in Saran, Champaran and Monghyr districts together. East India company earned

over £1,00,000 per year. In year 1631 about 3,33,000 lbs of Indigo was exported to Holland. Synthetic Indigo was discovered by Huemann in 1890 and as a consequence Indigo cultivation in India suffered and finally stopped. Earlier in the sixteenth-seventeenth century Indigo was prohibited over European continent for over a century, to give a boost to the European product viz. Woad (*Isatic Tinctoria*). Later in year 1860, synthetic Alizarin was made by Graebe and Liebermann, congo red by Bottinger in 1883 and Mauvine by Perkin in 1873. Thus, the synthetic dyes completely took over the natural dyes. This is a classic example of how adverse policies and lack of scientific research could harm native industries.

Although India had close contacts with Europeans in the formative years of the modern science, i.e., in the seventeenth-eighteenth and nineteenth centuries, modern science was late to appear on the Indian scene, which was only in the late nineteenth century AD. By mid-nineteenth century European scientists started coming to India. They were medical men, engineers, surveyors and also chemists. They were the ones who introduced India and some intelligent young Indians to the modern science. Though their works, scientific research was becoming known to the Indians, as a tool of investigation of natural phenomena and as a tool in the development of useful technologies.

As seen earlier surveying, geology, geography were the first modern sciences to be introduced to India. Civil engineering and medicine came after that. Chemistry was the last to enter the scene. A science college was established in Calcutta in the year 1814. The study of chemistry was first introduced in India in the Presidency College of Calcutta in 1872 and post-graduate teaching in chemistry in 1886. Earlier chemical researches were carried out by British scientists who were serving in India in capacities such as Assay Master in Calcutta Mint, by Robert Blake in 1792, chemist in British company by David Waldie from 1853 to 1889. He was the one who founded Cossipore Chemical Works at Kossipur in Bargal. W.B. Shaughnessy, was a chemical examiner with Government of Bengal and Professor of Chemistry at Medical College, Calcutta. He was Deputy Assay Master in Calcutta Mint. During his long stay in India between 1833 to 1860 he conducted researches in toxicology, chemistry, metallurgy, galvanic electricity and finally constructed the first telegraph line between Calcutta and Diamond Harbour.

Indian Association for Cultivation of Sciences was established in 1876. Early chemists like Chunilal Bose, P.C. Ray were actively associated with it. P.C. Ray was well aware and proud of the fact that Indians had made considerable progress in the field of chemistry during the ancient and the

medieval period, as seen in his two volumes on *History of Hindu Chemistry*. As regards to modern chemical research, around 1896 Ray studied the stabilities of metallic nitrites and hyponitrites and the action of nitric acid on metals. After Ray, Chandra Bhusan Bhaduri and Jyoti Bhusan Bhaduri were the ones who made significant research in the field of inorganic chemistry. They studied complex inorganic salts like copper-alkali ferrocyanide, sodium silver thiosulfate and constitution of drugs like *Andrographis peniculata*, chlorates and chlorites and also mercurous chloride which on decomposition gave chlorine gas. Seeds of research in physical chemistry were sowed by R.D. Phookan by studying rates of evaporation of bodies in the atmosphere of different densities. A campaign was started on the restoration of Āyurvedic medicine also.

Thus inspired by the new scientific spirit of the period and works of the early European scientists who resided in India under varied capacities and pursued their research, a band of young Indian scientists started taking keen interest in modern scientific research activities. At the same time they felt the need for native chemical industries, based on modern lines. P.C. Ray established the Bengal Chemical and Pharmaceutical Works Ltd in Calcutta, J.K. Gajjar with the help of Kotibhaskar and Amin established the Alembic Chemical Works in 1905 at Baroda. Vakil in 1937 established the alkali industry under Tata's patronage and Tata Chemicals came into existence. Thus Indian chemical industry was originated and it continued to grow with a slow but steady pace in the twentieth century.

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Spreading of the (Al) Chemical Myth (Word): Scientific Explanation, Historiography of Indian Chemistry, and History of Philosophy

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My aim in this paper is two-fold. In the context of doing research in history of Indian science, I want to raise general historiographical issues, especially those which arguably arise in history of Indian chemistry. In order to do that, I look at two Indian alchemical texts of the medieval period in India. These two texts, *Rasārṇavakalpa* and *Rasaratnasamuccaya* influenced by Brahmanical-Tantric ideas, offer a glimpse of the wealth of Indian alchemical/chemical/iatrochemical studies during the medieval period in India. Some preliminary analyses, of the two texts, also suggest new historiographical questions which need to be answered. Without answering them, I simply raise them in this paper. Second, I raise the question whether history of science, history of philosophy, and philosophy of science share an interface area for a fruitful investigation which illuminate issues in these areas.¹

This paper, viewed differently, has both substantive and programmatic aspects. The substantive aspect involves offering a tentative understanding of the notion of explanation in some of the alchemical treatises of the medieval period. The programmatic aspect involves raising the questions concerning historiography of Indian chemistry during ancient and medieval periods, and thereby suggesting a route for research in that area.²

INDIAN ALCHEMY

In this section, I discuss some aspects of the Indian view of alchemy/chemistry. In the process, I point out that historians of Indian alchemy and

medicine have claimed that some of the salient features of Indian alchemical view may be understood in the context of *Sāṃkhya-Pātañjala* philosophy. Although a discussion of the salient features of the *Sāṃkhya-Pātañjala* system may help towards an understanding of the alchemical/chemical texts, I do not attempt that here because the texts do not suggest any overt sense of dependence on this philosophical system. However, the texts are analyzed within the broader context of this philosophical system to the extent the textual evidence suggests employment of such categories. For example, it was accepted that there were only five basic elements which gave rise to all the other chemical compounds. It was also accepted that these elements were 'property-bearing' elements. The notion of 'property-bearing' will also be explained. In the context of the general philosophical milieu in which these alchemical texts were written reflect acceptance of a view of causation which offered an account of material and efficient causes. Next, it is claimed that the philosophical view prevalent at the time of writing of these alchemical/chemical manuscripts also employ certain 'mechanistic' categories to explain chemical phenomena. A preliminary, and thus sketchy, understanding of explanation of phenomena in the context of the theory of causation and the theory of chemistry and that of matter is offered. It is extremely difficult to abstract a clear picture of what would be considered as an explanation in this chemical/alchemical context. Finally, I look into the possibility of chemical explanation being a special kind of reductive explanation. I also look at some important features of Indian alchemical texts. I start with a discussion of these features.

One of the most attractive features of the Indian alchemical texts is the adoption of some Indian mythological themes. The question is: was Alchemy conforming to any particular tradition inspired by the idea and the symbolism of that time? Whether this form of expression is to be regarded as a rediscovery of the classical world is also to be established.

Those tales which the Greek called myths, or more properly in origins, 'words', have been attributed to the 'result of the working of naive imagination upon the facts of experience'. In most cases the myth is an account of the deeds of a supernatural being, or God, usually expressed in terms of primitive thought. It may have been an attempt to explain the relationships of humans to the universe. The mythologies survive for various reasons. One of these is allegorization. It is of ancient origin. It explains away the myth as an allegory, i.e., as a tale concealing deeper meaning, philosophical and moral, which must be withheld from those persons too ignorant and too impious to use it properly.

The emphasis which symbolism placed upon the spiritual aspects of

the art, taken together with the devaluation of the material possibilities of alchemy, removed alchemy from the hand of the gold maker. Alchemical work was also a spiritual quest to be followed only by adepts who truly understood nature. Nature was seen as active and animate. Thus, far from being passive and inert, dominated by forces external to them, individual bodies have their own sources of activities, whereby they set themselves in operation and perform specific acts. Since alchemy also expressed an organic view of nature in which no meaningful distinction of animate from inanimate existed, it perceived the whole of nature in organic terms. It understood processes that we regard, now, as entirely physical in terms of organic analogies. It held that metals/minerals grow in the earth. The non-efficacious metals/minerals when properly treated yield gold. This is because that these non-precious (both in the sense of being a baser metal as compared to gold and also in the sense of being therapeutically less efficacious) metals are in some sense products of aborted natural processes. The nature was seen as psychic. Projecting the mind onto nature, it understood the characteristic actions of bodies in similar terms. Bodies exercise influence on each other. Such a concept of natural action implied that agents are specific rather than general in their operation. The attraction of like for like was one of the characteristic ideas.

In Indian alchemy, there underlies also a world view to the effect that human (a microcosm) is an epitome of the universe (macrocosm). Both universe and human are manifestations of one and the same eternal spirit. The spirit and matter underlie both. Following the *Sāṃkhya-Pātañjala* system, both result from the evolution of *prakṛti*. At a more mundane or gross level, both are constituted of the same primary elements or principles. The same causal principles underlie phenomena in both realms. Thus, *prakṛiti* has eight aspects: *avyakta* (the unmanifested ground), *mahan* (ultimate experience), three fundamental *guṇas* (*satva*, *rajas*, and *tamas*), and three *ahāṅkāras* (guidance, energy, and inertia); and sixteen mutations: five organs of perception, five organs of action, the mind and the five *tanmātras*. The *pañcabhūtas* constitute all material substances. These *pañcabhūtas* have different properties. Thus, the *Earth* principle gives mass, hardness, compactness, roughness, inertia, density, opacity, smell, and tactile sensations. The *Aṇu* principle gives fluidity, viscosity, coldness, softness, unctuousness, and taste. The *Tejas* principle gives visibility to objects, colours, periodicity of motion, digestion, anger, instantaneous response, courage, and visual sensation. The *Vāyu* principle gives perception by physical contact, all physical and physiological movements, pulsations, sense of lightness and the tactile sense. The *Ākāśa* principle gives sound, porosity, bodily cavities, functional

subdivisions of the bodily channels and tissues into finer and finer branches, and the sense of hearing. The medical as well as the alchemical texts of that time assumed that both macrocosm and microcosm are composed of all the five elements in different proportions and their properties result from the particular combination and composition of the different principles.³

There is yet another aspect of Indian alchemy which deserves mention. First, these texts are influenced by Tantric way of life. Thus, we see reference to not only transmutation of base metals to gold but also bestowal of psychic powers on humans. This is referred to as *kāyāsādhana*, *dehasiddhi*, or *kāyākalpa*, a type of physical culture to become divine. This physical culture was performed by various means, like, practice of *yoga* and *āsana*, and intaking of elixirs. This intaking of elixirs, was thought to help attain *siddhi*.⁴

The two texts I consider here are of somewhat different kinds. Both texts share two major alchemical goals but the emphasis given on one (therapeutic) goal is more in *Rasaratnāsamuccaya* than in *Rasārṇavakalpa*, which emphasizes the efficacy of making gold. It does not mean that *Rasārṇavakalpa* did not have as one of its important goals, changing of the old to youthful state. In fact, the emphasis was on transmutation of baser metals to gold because gold, being the perfect metal is capable of being used as a drug both for restoration of youth and for curing diseases. *Rasārṇavakalpa* is an older text and primarily an alchemical text. It also contains ritual matters intermingled with alchemical ideas. Roy and Subbarayappa point out that 'the style of expression with symbolic connotations of those parts are to some extent obscure and enigmatic'.⁵ *Rasaratnāsamuccaya*, a well-known text of Indian Alchemy/Chemistry, Āyurvedic pharmaceuticals and therapeutics, belongs to the later medieval period (AD 13th Century). It deals mostly with the drugs of mineral origin. Before I discuss a few interesting aspects of either text, I summarize below a few general points made by historians of chemistry regarding these texts.⁶

Indian alchemical tradition developed important procedures and techniques necessary to extend the extent of use of mineral drugs. The development of pharmaceutical techniques had started from the time of *Caraka Saṃhitā*. The text describes several procedures/techniques/operations which enhance the therapeutic properties of the original materials or induce in them certain new properties useful for the body. Following the text's terminology of *saṃskāra* (for the pharmaceutical processes and operations) one can say that 'these *saṃskāras* were responsible for *Cuṇāntarādhāna* (including new or alternative properties) of the materials to be used for therapeutic

purposes. Some examples of these techniques responsible for Guṇāntarādhāna included *Toya Sannikarṣa* (contact of drug with liquid), *Agni Sannikarṣa* (contact of drug with fire), *Toyāgni Sannikarṣa* (contact of drug with both liquid and fire), *Śaucha-Śuddhikaraṇa* (purification/detoxication—external as well as internal), *Manthana* (churning or grinding, i.e. digestion of the particles), *Bhāvanā* (addition of the same or different extractives with or without grinding) and *Vāsana* (flavouring). In addition to these procedures, the following factors were also admitted as the ones which were likely to influence the properties of the drugs during their processings: *Deśa* (place of collection/preparation of drugs), *Kāla* (time/season/duration of the collection/preparation), *Bhājana* (influence of the containers during preparation/storage of the drugs), and *Kāla Prakarṣa* (effect of passage of time/long duration on the efficacy of the drug).⁷

The main concept of *Rasa Śāstra* is to transform base/lower metals into noble/higher metals, to strengthen the body tissues and to maintain them in a fresh and healthy state so as to remove poverty, senility, diseases, and death from the world. Besides these, disease curing aspect is also included. Thus, *Rasa Śāstras* were developed to achieve *Lohavedha* (transformation of metals) and *Dehavedha* (transformation of body for the prevention of ageing and diseases, and maintenance of positive health). Further, to achieve *Dehavedha*, *Rasa Śāstra* stressed more on *Rasāyana* concept of Āyurveda.⁸ The *Rasāyana* concept advises the ways and means by which one can achieve best quality of *rasādi dhātus* (body tissues) which in turn provide positive health to the body and prevent diseases and ageing, and thus sustain our body always in a healthy and youthful state. Historically, the *Rasa Śāstras* developed the concept of *Rasāyana*. Thus, from eighth century AD a number of metallic and mineral preparations were evolved and recognized to possess *Rasāyana* property, which on continuous internal use would maintain the body health, prevent ageing and the onset of diseases. If required, these may also be used for curing diseases. It must also be mentioned that in *Rasa Śāstra* the metals and the minerals are also termed as *Dhātus* and *Upadhātus* because of their specific role in biological systems, i.e., these can sustain body tissues by supplementing some of the essential elements to the tissues, whose deficiency causes many undesired problems/diseases in the body.⁹

In the *Rasa Śāstra* and *Rasa* therapy the use of mineral drugs especially that of mercury and of sulphur (the most basic materials) were recognized. It was also recognized that these drugs were toxic. In order to reduce or remove their toxicity a number of *śodhana* measures were developed. 'These include grinding of such drugs with vegetable extractives and with other acidic or alkaline liquids, their heating and dipping in various liquids, or

their boiling, fusion, sublimation, etc.; measures which in turn remove washable/soluble and/or volatile impurities of the drugs of mineral origin. Sometime some organic/inorganic materials are added either in traces or in large amounts to these substances which helped either in their detoxication or in their potentiation.¹⁰

By *mārana* process the drugs of mineral origins are converted to a fine ash form suitable for systemic absorption. To achieve this, the drugs of mineral origin are first subjected to *bhāvanā* (grinding with some vegetable extractives and acidic liquids) and then to *puṭapāka* (heating through scheduled heating system) several times. With the development of *Rasa Śāstra* more processes were developed. For example, in the case of *abhraka*, the method of *dhānyābhraka* is mentioned in between *śodhana* and *mārana* processes. In the same way, an intermediary procedure known as *jārana* was developed for *nāga*, *vaṅga* and *yaśada* with a view to convert these low melting/easy fusing metals into a powder form. They also developed various kinds of *mārana* drugs for increasing or decreasing the efficacy of the drugs being converted to ashes. They mentioned that if mercury or its compounds are used as the *mārana* drugs before employing the actual *mārana* process, the finished products will be of very high quality. In this method, though mercury is not found present in the final product, still it is claimed that the *bhasma* so prepared may be inducted with certain special properties and thus the product becomes more effective than the products made by other methods. *Mārana* with vegetable extractives is second best because the *bhasma* would be devoid of the properties of mercury and sulphur. *Sattvapātana* is another important process which help release the *sattva* (metallic content) of a mineral or a rock. *Druti* is another important process in which metals are converted into a *druta* (stable liquified state).¹¹ A cursory glance at *Rasārṇavakaḥ* seems to point out that they employed various kinds of processes to purify, and extract required materials. There are at least thirty or more different kinds of processes which are mentioned in *Rasārṇavakaḥ*.

Mercury having been *mūrcchita* (compounded) destroys diseases, having been solidified/bound/fixed provides emancipation and having been converted to ashes makes the person immortal; hence there is no better compassionate substance than mercury. One can achieve liberation only by achieving perfect knowledge through continuous practice, possible for one with a sound physique. No *Rasāyana*, either only of vegetable origin or only of metallic origin, is capable of making the body physically sound because these themselves are unstable as these can be burnt, moistened and dried.¹²

Although the *Rasa Śāstras* discussed to a large extent the *Rasāyana karma*, the *loha karma* or *rasa karma* aspects were not completely neglected.

Thus, we see that there are discussions or mentions of substances which are efficacious for *loha karma* or *rasa karma*. This we see especially in *Rasaratnasamuccaya* which was a late thirteenth or early fourteenth century iatrochemical text. Similar emphasis on *rasāyana karma* is seen in most of the iatrochemical texts.

The properties of mercury described in *Rasaratnasamuccaya* show that there are five types of mercury (or *Rasa*). The descriptions imply that *Rasa* is an agent. It performs certain activities by virtue of its power. Its form is liquid. Also, depending upon its situation, it can be associated with the motion of soul and attain *jivagati*. Hence, mercury is also called *Jiva*. If we consider the therapeutic and alchemical properties of the eight *Rasas* we find that the following important features stand out. First, these, when treated with 'proper' herbal juices, achieve some special properties. For example, these can 'destroy' various kinds of diseases. Since the most important goal of a *Rasa Śāstra* is to provide knowledge about *Rasas*, their properties, their efficacies in maintaining health of humans so that humans can attain *dharma*, *artha*, *kāma*, and *mokṣa*, the knowledge that is provided in *Rasaratnasamuccaya* or any other alchemical texts is a list of various substances and the methods of making them (more) efficacious by treating them with various herbal/vegetable plants. The underlying method assumes that one has to experiment and then determine what are the important substances which achieve the goals. An analysis of the text reveals, e.g. that mercury having consumed *abhraka* as a solute is good for both *loha karma* and *rasāyana karma*. There is also a list of several processes with *abhraka* including *satva*. In only some of the cases the properties of the products are mentioned. This seems to lend credence to the belief that at least some, if not all, of these different products were tested for *rasāyana karma* adequacy. This experimentation and determination is also guided by some method. For example, consider how the author in *Rasaratnasamuccaya* attempts to correlate the alchemical uses of *abhraka* with that of its colour. White *abhraka* is used to prepare silver, while red *abhraka* is used for dyeing, and yellow is used for gold making. This recommendation perhaps assumes the following understanding. At least some properties, of a product, is dependent upon the properties of its constituents. The colour property, e.g. can be transferred by the component substance to its compound. Consider again, the case of another *rasa*, *Śilājatu*. The first interesting point is that it is of two types—*sasatva* and *nissatva*, i.e. with therapeutic power and without therapeutic power. Thus, it is the presence or absence of *sattva* in a substance which determines whether at all the substance has any kind of

power. Second, the *nissatva* variety is still *śilājatu* though of the inefficacious kind. Thus, its nature as *śilājatu* is not changed though it lacks a certain therapeutic property. We also see, from the text, that *śilājatu* obtained from the gold-containing mountain rock is reddish in colour. It is the best *rasāyana*. *Śilājatu* obtained from silver containing mountain rock can cure some diseases, while that obtained from the mountain containing copper rocks has no therapeutic power. This seems to imply that the circumstance of this *rasa* both in terms of its specific location (and hence in terms of the process of its production) and/or interaction with the specific environment in that location play a significant role in determining the therapeutic property of it. Gold-containing rocks must play a role in making *śilājatu* the best *rasāyana*. The presence of gold either facilitates the process or takes an active role in the process. Since gold is the goal of alchemical research it would seem that it would play an active role in the process. Since silver is the next best metal its effect is much less. The question is why is it that the circumstances provided by silver containing mountain is less efficacious. I suggest that it is because the process which gives *śilājatu* its therapeutic property is aborted or modified in this case. The circumstances play a causal role in inhibiting the process leading to the said substance obtaining the best therapeutic property. Similar example of aborted process is mentioned in *Rasārṇavakalpa*.¹³ Thus, gold, obtained from a base metal, treated with mercury prepared with the juice of *tṛṇauśadhis*, is up to the half way level as attained in the case of a total (perfect) conversion. Before I consider what interesting philosophical implication these examples have I want to mention a few more interesting examples.

We also see that mercury prepared in various ways have different powers of transmutation. Some preparations can bestow mercury to convert base metals million times its weight into gold, or convert it by mere touch, or by showing the mercury to the metal. Or, gold prepared in some way can bestow *dharma*, *artha*, *kāma*, and *mokṣa*, while prepared in another way, it is less efficacious and can help attain *dharma*, *artha* and *kāma*.¹⁴

We next briefly consider another substance (discussed in some detail in *Rasaratnasamuccaya*), sulphur. The description of the mythological origin of sulphur and its properties reflect the belief in *Śiva-Pārvatī* union at the cosmic level. Thus, mercury and sulphur union at the microcosmos level is analogically the same kind of union at the macrocosmos level between *Śiva* and *Pārvatī*. Hence, sulphur also has a very superior *rasāyana* property. This kind of analogical reasoning plays an important role in not only ascribing an important therapeutic role to some substances but also in justifying or

substantiating the alchemists' belief in the (therapeutic) efficacy of some over the other. The archetype of *Śiva-Pārvatī* union at the level of cosmos reinforces the desirability of the union of mercury and sulphur at the microlevel.

The examples that we discussed above regarding the production of different kinds of *śilājatu* or gold, seem to raise the following plausible explanation for the difference in the final product given the difference in circumstances. Suppose it is held that a universal cause, U, is causally responsible for bringing about the production of both kinds of *śilājatu*, say S1 and S2. One way one could explain that, would be to appeal to different environmental circumstances. The environmental circumstance, E1, along with U are causally responsible for the production of S1, while the environmental circumstance, E2, along with U, are causally responsible for the production of S2. We need to remind ourselves that S2 is the product of an aborted (modified) process which otherwise would have given us S1. This means that E2 played an important causal role to help abort the process. The reason one holds that the process was aborted is due to the fact that the product (S2) of the aborted process can be transmuted to S1 by another process. While this may broadly be in accordance with *Sāṃkhya* account of causation, the alchemists might not have strictly followed this view. It is not clear whether they wanted to posit the first material or efficient cause to explain the production of different kinds of *rasas*. In fact, one may want to refute this thesis because one may claim that this involves positing a first cause, U. In order to look at this refutation let me first make explicit the thesis (of Universal Power) that one is trying to refute. The thesis has two parts: (1) the cause of *rasas* is a certain power, which is one in all things; (2) the power varies greatly in proportion to the material that receives it and the circumstances the material is in; hence, *rasas* with different therapeutic properties are produced in different places. It appears that this thesis is extremely plausible. I will first raise a plausible objection and then go on to evaluate it. The objection is that we are looking for *immediate* material or efficient causes existing in the material and transmuting it. And if the above claim was correct, then, once we knew the universal cause producing *rasas* we should know the cause of everything that can be produced. This is because the effect of the environment (E) is to modify the power of the universal cause such that the process is carried through in one case, while it is aborted in the other. We know that the motion and powers of the elemental bodies are the ultimate causes of things. But these perhaps are acting causes in a different sense, since they have nothing in common with the materials of the things that can be produced. But, in accordance with the proper methods of natural science, we should look for causes appro-

priate to their effects, and especially for the material and whatever transmutes it.

The above refutation can be systematically expressed as follows:

- (1) The first cause for action and movement is the power of the elemental bodies.
- (2) We need *immediate* causes, existing in the material and transmuting it.
- (3) If a universal power is the *immediate* cause for the production of *rasas*, then once we know this cause we can know the *immediate* cause for producing anything.
- (4) The consequent of the conditional statement in (3) is false because we know that the universal power is different from natural (*immediate*) causes.
- (5) A Universal Power is not the *immediate* cause.

One can also object that a Universal Power is an equivocal cause. But in natural science we are looking for univocal cause. Hence, the Universal Power cannot be an *immediate* cause for the production of non-precious metals or inefficacious *rasas*. Let us look at the first argument. It appears that the most crucial premise in the argument is the premise (4). There are several arguments for establishing this premise. Before we go into that let us explain what one may mean by *immediate* and remote (efficient?) causes. Thus, we say a man is healthy because physician healed him. Physician healed him by the art of healing he possesses. The former is the *immediate* and the latter is the remote (efficient?) cause.

One way to argue for premise (4) is dependent upon the second argument outlined above in the last paragraph. This argument is dependent upon the notion of causes acting in the equivocal sense. This, in turn, depends upon the general metaphysical belief that nature is the seat of powers from which the powers pour into the material. Since the same nature produces various kinds of things, it uses other causal agents instrumentally. The assumption here is that we should look for causes acting univocally. One thinks that only the knowledge of these kinds of causes, which are appropriate to their natures are useful in natural philosophy. Thus, an explanation of a phenomenon is good at the first level if one posits an immediate (efficient?) cause in a univocal sense for an effect. But there are several kinds of phenomena in nature. To explain these as effects under a general causal principle would require a deeper and broader explanation. Thus, the causal principle invoked has to be equivocal in sense. An analogy may help to understand the situation better. Knowledge generically helps one

to build or make many things. But only specific knowledge of healing in a physician makes him a physician. A physician can be said to heal by knowledge. But more specifically, a physician can be said to heal by the knowledge of art of healing that he possesses. If we say knowledge healed this man and similarly knowledge built this building, then one might think that if we possess the knowledge that healed this man, we can make this building by the same knowledge. But this of course is not correct. Thus the premise (4) is established beyond any reasonable doubt since the power that causes one *rasa* is not the same power that causes another *rasa*. These two causes or powers are different so long as these are immediate (efficient?) causes. That the alchemists confronted this tension between search for univocal and equivocal causes, although perhaps unknowingly, is obvious and will be hinted below when we discuss their methodology and plausible modes of scientific explanations suggested by their work. The tension was generated more because the theoretical explanations of chemical phenomena lagged far behind the practical explanation of the phenomena. I now turn to that aspect in the next section.

Methodology and Explanatory Schema in (al) Chemical Works

At the time when these treatises were written, the traditional explanations of the (al)chemists could be interpreted as follows. Mundane objects were made up of 'principles' or elements which *conferred* properties upon the materials of which they were constituents. Such a mode of explanation, would be congenial to a chemist/alchemist/iatrochemist with empirical interests, suspicious or unaware of too much theory. Consider what a theoretical explanation of a chemical or therapeutic or alchemical property would be like. From the point of view of *Sāṃkhya-Pātañjala* system, the explanation is very complex. Thus, for example, the 'isomeric' modes of each *Mahābhūta* have specific colour or taste due to their structure, i.e. the arrangement of their *paramāṇus*, and the various properties of compounds arise from the collocation in unequal proportion of the different forces latent in the *paramāṇus* of the component substances. A new substance may arise by the interplay of Energies within the system of any given substance, in the absence of any action from without. New qualities like new substances are only readjustments of the old, and continual changes are going on by spontaneous disintegration and recombination.¹⁵ It is extremely unclear what practical information in terms of getting an idea of a univocal cause can be obtained from such deep theoretical explanation. Also, the practicing (al)chemists had a real need for explanations of the phenomena/properties

such as, colour, efficacy in curing certain kinds of diseases, or in prevention of diseases, or promoting health, to name a few. Among the (al)chemists, explanations in terms of the definite material substances would be favoured more on the practical ground. To say that the cause of colour lay in the specific principles would be to offer the prospect of *useful* explanations of a range of (al)chemical phenomena. Or, to say that the efficacy of certain kinds of drugs is due to the presence of a certain kind of substance or principle would help prepare and use that drug. The explanatory schema this view suggests is as follows.

Let a compound, C, have properties P1 and P2. Let that compound be decomposed to determine its constituents. Let these constituents be E1 and E2. The properties P1 and P2 can now be explained in terms of the properties of E1 and of E2. The explanation will proceed as follows. Either E1 or E2 or both E1 and E2 have the properties P1 and P2. These properties (P1 and P2) are essential properties of E1 (or of E2, or of both E1 and E2). Therefore, the whole has a property because the part has that property. Thus, to take an example, C has the property of being solid. One of the constituents of C is earth. The earth has the property of being solid. So, the property of being solid is conferred to the whole compound C. This kind of explanation appears to be a weak form of reductive explanation. For, in this kind of explanation, the whole has a property by virtue of its part having the same property. This of course does not mean that the whole has a property because every physical part of it has that property. Thus, the explanation of why this substance is therapeutically efficacious is not given by appealing to the therapeutic efficacy of its physical parts but by appealing to the therapeutic property of, say, one of its constituents. The therapeutic property that the compound has is a property of the whole and isotropic and independent of the mass of the body.

Interestingly enough, the alchemists/iatrochemists of that time also allowed that any compound has some specific property that distinguishes it from its constituents. However, they are silent as to what kind of explanation one can give for such properties. One might think that sometimes C exemplifies a property not merely because the constituent has that property but also because the constituent is in a particular physical state. The physical state is described in terms of motion and degree of tenuity of the particles of the constituent. Thus, the physical state helps to make the property manifest. The physical state of a constituent can hasten or slow down a particular process of combination or resolution. The question then is, can a substance have the chemical property of reacting in some specified way, which becomes observable only when that substance is in a particular

physical state? It is unclear what the answer could be. Now, how is that property to be explained? I think, one would claim that the constituent is in potentiality with respect to such a particular state of having that property. The reason, I expect that such an answer would be appropriate is because, first, fire or air or even water can act as instruments. It is true that water is a principle. But water as an instrument, much like other instruments, do not change the essences of the constituents. Second, the alchemists use dispositional property like being disposed to be solid, etc. Thus, it would seem very reasonable that a dispositional property needs to be understood in terms of potentiality.

However, the question remains whether this reductionism, if it really is a reductionist programme, is a trivial kind of reductionism. I think it is not. Because, it seems these (al)chemists need to give us an account of the dispositional properties of the 'property-bearing' elements. And this account needs to be given in the context of their theory of elements and theory of causation. One way to account for these properties is to invoke the notions of actuality and potentiality. These concepts are conceptually connected with the concept of motion. Thus, what is entirely in potentiality is not moved yet; what is already in complete actuality, is not moved but what has already been moved; what is partly in potentiality and partly in actuality, i.e., what is intermediate between pure potentiality and pure actuality is moved.

It appears that explanation schema in the alchemical writings we considered follows a very weak reductive strategy in which the property of a compound is explained by positing the constituents which make up the compound has that property. Thus, the whole has a property because its part has that property. However, it is unclear how the dispositional properties are explained. It is also not obvious how we can explain the specific property of a compound which sets that compound apart from its constituents. In fact explanations of the last two kinds of properties may be strong reductive explanations with property-identities. But I am not sure. It is possible that these works can be understood completely in terms of medieval theory of causation and five principles of elements and the theory of motion. We need to remember that for the philosophers/chemists of the medieval period causes are always things. A thing has a particular power to do what it does. It may use its power by itself or if it is an instrument its power is used by an agent. Thus water has power to move certain things. But it exercises its power only as an instrument under certain conditions. Or knife has a power to carve things. But it exercises its power only through an agent who uses that knife to carve, say a piece of marble. And I am not sure if a chemist would like to ask why is it that knife, as knife, has the power to carve.

I want to close this section with the following comments. The exercise above involving outlining of some of the salient features of the two alchemical texts and subsequent attempt to abstract an account of scientific explanation raises some important methodological questions. First, does history of science has any role to play in doing a more fruitful history of philosophy? Second, does one need to do history of science to illuminate issues in philosophy of science? I will not attempt to discuss the answer to the second question except to point out that my inclination is to answer the question in the affirmative. In proposing an answer to the first question, I start by pointing out that an important activity of philosophy is taken to be a painstaking clarification of the fundamental concepts and questions. How does history of philosophy fit in this schema? One answer would be that history of philosophy can be seen as a progressive clarification of the questions that have been raised since the ancient days and evaluations of various answers to these questions. Though this answer is innocuous enough, it is not and cannot be the correct account. One would like to know whether philosophy at different times raises the same questions? For example, did the philosophers of one period mean the same thing by an explanation of a phenomenon as the philosophers of a somewhat previous era? The question is hardly rhetorical. It is not an *a priori* given to us that the philosophers of different times separated by hundreds of years understood the same thing by the same question, or could evaluate answer to a question by applying the criteria which need not have remained unchanged. If they did not, then their answers to the questions cannot be evaluated by appealing to an eternal criteria of evaluation. And if they did, then it is a historically contingent fact and to be established by historical research and scholarship. Even then the criteria employed for evaluations, could be different. More likely, the nature and type of philosophical questions raised at any time would reflect the cultural/intellectual milieu of the period. This *a posteriori* aspect of history of philosophy thus raises the following question about the analyses of alchemical texts provided above. The notion of explanation that was abstracted from the analysis may be an answer to a question raised in the context of the present philosophy of science. Did the alchemists raise questions about explanation? In the next section, when I discuss the problems of historiography of Indian chemistry, I mention that the alchemists might have implicitly viewed their work in the tradition of elaborating a *prayojana śāstra*, without feeling the need for developing any methodological prescription which would be philosophically defensible. In that context, the attempts to be able to prepare substances, with specific properties, with ease might have provided the overriding consideration for experimenting,

elaborating, and systematizing the already established body of knowledge. The questions concerning deep theoretical explanation of phenomena or properties were simply not raised in this narrow context.

Historiography of Chemistry

In this section, I want to raise some issues concerning the historiography of Indian chemical traditions. Let me mention in passing that even in the western historiographic tradition, chemistry occupies a subsidiary position in the historiographical hierarchy. Only a few historians are interested in history of chemistry or of alchemy. If we compare that with the ever increasing amount of work on history of physics, or of biology, we find that chemistry has been a neglected discipline indeed. Added to that is the apology that chemistry, as a discipline, had to offer by attempting to delineate itself from alchemy (Tantric work in the Indian context).

History of Indian chemistry (or alchemy) has suffered as much as the history of western chemistry because of the chief preoccupation of the Indian chemists and historians with two views. First was (and to some extent still is) to understand Indian chemical works or traditions mainly from the point of view of the present knowledge of chemistry—more particularly that of atomism. The historians of Indian chemistry were, or still are, very much preoccupied with chemical atomism of the west. Hence, what goes on in the name of presenting, justifying, and legitimizing Indian chemistry of the ancient or medieval times is an elaboration of various philosophical systems, e.g. the *Sāṃkhya-Pātañjala* system or the *Nyāya-Vaiśeṣika* system (especially Kaṇāda's view), or the Buddhist view, or the Jainist view of atomism or theory of matter. We are also given accounts of different theories of causation offered by these different schools, the account of explanation, and an account of certain allegedly chemical concepts, e.g. chemical compound or mixture. Although I have not the slightest reason to claim that these exercises are not important for a better understanding of Indian chemical/alchemical systems, still what I find extremely problematic is that such exercises seem to be the only kind of legitimate historiography that we are offered. What is not recognized is that this historiography has two major inadequacies. First, it is centered around the western concept of modern chemistry—especially of atomism. Second, it borrows, by virtue of its acceptance of chemical atomism of the west as a provider of perspective, the categories of western science (in this case, of chemistry) and applies it to a product of a different cultural milieu.

The other significant drawback, which follows from the presentist

historiography, affecting the Indian chemical historiography, is the temptation to present a modern chemical analysis of some of the chemical/metallurgical artifacts, or a listing of various chemical operations. The reason for presenting such a list is unclear unless we want to point out that Indians in the ancient period were aware of or had the knowledge of certain techniques or perhaps the knowledge of certain materials which the Europeans did not. The question, however, remains as to how or why presentation of such results should add to our understanding of Indian chemistry. After all we are not attempting to prove that our ancestors had some knowledge, in the presentist sense, which, by the fall of Grace or whatever, were lost in the dark ages. If that is what we are trying to do, then this is hardly any basis of sound historiographical exercise. We cannot legitimately claim that the operations listed in the (al)chemical texts mean the same as the operations that we find in modern chemistry textbooks. To claim that an *amla* substance is an acidic material is to run aground with the historical sensitivity required to understand the past in its own terms. Simply put, a history that does not disown its presentist categories distorts the past and is no history at all. Lest I might be thought to be someone fighting a straw person, consider Professor P. Ray's *History of Chemistry in Ancient and Medieval India*, still the only major work on history of Indian chemistry. This work is an edited version of Acharya P.C. Ray's two volume work titled *History of Hindu Chemistry*. The actual reasons for Acharya Ray's motivations for this research, which might have included resurgence of aspirations of Indian nationalism do not need to be discussed here. But Professor Ray's edition reflects the worries of a western-science trained chemist. Hence, we are told, e.g. while discussing Tantric (alchemical) literature, that this literature contains descriptions of important chemical phenomena. A cursory glance of the choice of (translated) slokas printed in the book reflect the inclination of the author concerning what constitute important chemical phenomena. These phenomena are those which could be understood from the point of view of modern chemistry. Problems of different sort arise when we look at professor B.N. Seal's work.¹⁶ There we have an elaborate account of various philosophical systems. This is important no doubt, but it is inadequate because it does not attempt to even start to bridge the gap between alchemy and these philosophical accounts. It fails to discuss Indian alchemy with seriousness the subject deserves. Of course, there are exceptions. Thus, we have Joshi's pioneering translation of *Rasaratnasamuccaya* and Roy and Subbarayappa's translation of *Rasārṇavakaḥ* (although the text does not include the first fifty-two *slokas* for reasons that are unclear).

I conclude that the historiography of Indian chemistry thus has suffered

doubly. It has suffered because the presentist historiography was imposed in analyzing chemical/alchemical texts. It has also suffered because the western concept of chemical atomism, with its conceptual baggage, provided the Archimedean point for our historical research into Indian chemistry. This dominance has primarily led us to look for those strands in the Indian chemical tradition which could be interpreted as, or which are, a species of atomism. Instead of succumbing to this historiography, I want to raise and consider a plausible and viable alternative which might redress some of these problems. This involves, following Christie and Golinski (see note 2), considering 'the question of the nature of chemistry as a historical practice'. When we talk of chemistry, of course, we want to consider the subject matter of chemistry, modes of investigation in chemistry, delineation of chemistry from other branches of knowledge as something which are historically contingent and not given to us *a priori*. It needs to be understood that the practice of chemistry both in terms of production of material objects or of knowledge claims and in terms of dissemination of that knowledge are socially and culturally governed. Thus, human beings play an important role in producing such cultural artifacts as specific chemical objects or specific chemical texts. Viewed from this perspective, the role of philosophical systems is not to be belittled but may not be given undue prominence as well. The roles of epistemology, metaphysics, or theology, etc. are to be taken into account but only to the extent these (contingently) inform the cultural practice called alchemical/chemical work. By following this approach, one avoids the possibility of subsuming history under a specific philosophical schema. Consider one of the thematic centers of the proposed historiography. It is known that there were many chemical/alchemical manuscripts written between the ninth and sixteenth centuries. What do these manuscripts serve as? These, I claim, following Christie and Golinski (see note 2), are 'the cultural artifacts of that specific period'. They embody certain understanding of the nature. But more importantly, these texts serve some important purposes including that of didactic purpose.¹⁷ It is an open question, one to be resolved by historical research and scholarship, whether writing such texts were a part of a long tradition. To answer that question, one has to ask whether there was a formal tradition of disseminating alchemical/chemical knowledge, what kinds of historical conditions helped preserve that tradition, whether the manuscripts of the texts were circulated, and among whom were these circulated, thereby providing 'a further means of cultural transmission'. Also, question can be raised whether the didactic form imposed any constraint in presenting the material and in conceptualizing the body of (al)chemical knowledge. It may also turn out to be the case that there

were varieties of formal traditions. Consider the Introduction of *Rasaratna-samuccaya*. The author gives credit to a long list of people in compiling this treatise. What purpose did this particular text serve if it was a mere compilation of some already known alchemical processes? Even if it did provide with some new methods, in this case it actually did, was it supposed to pass on this information for the sake of posterity, or was it supposed to be used as a text for didactic purposes as well? As pointed out before, Subbarayappa mentions in one line in his introduction to *Rasārṇavakalpa* that it also served didactic purposes. He is completely silent regarding who taught, and to whom, where was it taught, what did the students subsequently do, was it the only text that was taught, or was it one among many? Answers to these questions are crucial to understand the nature of Indian chemistry/alchemy.

Next vexed question deals with the method employed in writing the text. An analysis of the ordering of the subject matter of the text should give us insight regarding what constitute important chemical practices and important chemical concepts. Given that most, if not all, of the alchemical/chemical texts were written to serve specific medical goals of providing good health, which in turn was necessary to achieve liberation, and given that objects from mineral, vegetable, and animal kingdoms were mixed together and processed reflect a lack of hierarchy from the point of view of efficacy of medicines produced from species in one particular kingdom. Yet another question which needs to be raised and answered is the role of natural philosophy in informing these texts. What I have in mind is not so much imposing one philosophical system or another on the text but to worry what motivated some of these writers/alchemyists/practitioners of medicine to assume an analogy between the working of the cosmos (macro level) and the human body (microcosm). How the working of the human body was modelled after the working of the cosmos needs to be explored. I will raise another important question before I end this section. In many alchemical/chemical texts we are given an account of a *rasaśālā* where all the operations of *rasa* are performed. Now, there are specific instructions as to how it is to be set up, and what operations are to be performed there. Joshi's suggestions notwithstanding a deeper understanding of the geography of the *rasaśālā* will illuminate our understanding of the analogy between macro (cosm)-micro (cosm). It is a place where elixirs are prepared. These elixirs either help give a long life or transmute a metal other than gold into gold. Thus, the cosmic power is localized in the specific substances produced in a specific way in a specific place. The role of metaphysical world views in setting up the *rasaśālā* is something that must have played an important part in practicing alchemy.

Finally, I want to raise briefly the point that alchemy/chemistry of the period we are talking about here, is also to be understood as *prayojana śāstra*. This only means that these have some definite goals which are mundane and are not necessarily developed with an esoteric goals of providing a deeper understanding of nature. As a result, most practitioners might not have found the need to justify it by appealing to a specific philosophical system. The teleological concern for ensuring the health of a person which in turn will help him/her to achieve *dharma*, *artha*, *kāma*, and *mokṣa* is the primary concern. To that extent it shares the concerns with Āyurveda. But it differs from Āyurveda to the extent that it also aims at transmuting base metals to gold, although to achieve the primary goal. And it visualizes the world as a seat of power, and humans as the microcosm of the powers in the world. Seen from this perspective, a serious study of Indian alchemy should provide the conceptual apparatus underlying the activity, both in terms of its practices, and knowledge claims. If the discussion in the previous section is any indication, questions regarding the problematics and hard to get at notion of, e.g., scientific explanation perhaps have to be raised and understood in a very different way from the way it is raised and answered in the western analytic tradition.

NOTES AND REFERENCES

1. My discussion in this paper has been strongly influenced by two programmatic papers. These are Professor D.P. Chattopadhyaya's, 'On the Nature of Interconnections between Science, Technology, Philosophy and Culture', Occasional Paper 1, Project of History of Indian Science, Philosophy and Culture; and Professor R. Kumar's 'Reflections on the Proposal: A History of Science, Philosophy and Culture in Indian Civilization', Occasional Paper 3, Project of History of Indian Science, Philosophy and Culture. I also acknowledge the keen interest shown in this work by Professor N.C. Nigam, Director, Indian Institute of Technology, Delhi.
2. My indebtedness to J.R.R. Christie and J. Golinski's paper 'Spreading of the World', *History of Science*, 22 (1982), 235-66, is acknowledged. The title of my paper reflects my indebtedness.
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4. Roy, M. and Subbarayappa, B.V. (tr.) and (eds), *Rasāṃśavakalpa* (New Delhi: Indian National Science Academy, 1976), pp. 3-4.
5. *Ibid.*, p. 2.
6. I rely for my discussion here mainly on two references cited above and on articles by Subbarayappa, B.V., 'Chemical Practices and Alchemy', in *A Concise History of Science*

in India (New Delhi: Indian National Science Academy, 1971), pp. 274–338; see especially pp. 209–38; and by Joshi, D. (tr.) and (ed.), *Rasaratnasamuccaya*, *Indian Journal of History of Science*, 22 (1987), 24 (1989), and 27 (1992) (published as supplements). See especially 22 (1987), supplement, pp. 1–17.

7. Ibid.
8. For a somewhat different interpretation of the concept of *rasāyana*, see Roy and Subbarayappa cited in note 2. However, Majumdar's view is similar to that of Joshi.
9. See note 7.
10. Ibid.
11. Ibid.
12. Ibid.
13. That the alchemists held the view that circumstances can abort or modify natural processes is borne out from textural evidence. See especially, *Rasārṇavakalpa*, pp. 107–10.
14. *Rasārṇavakalpa*, see pp. 64, 66, 72 and 74.
15. Seal, B.N., *The Positive Sciences of the Hindus* (New Delhi: Motilal Banarsidass, 1958), see especially pp. 23–53.
16. Ibid.
17. See Roy and Subbarayappa cited in note 2; p. 1. They acknowledge that the style of writing reflects the didactic nature of other Sanskrit texts but do not follow up the suggestion.

The Scientific Temper and the Scientific Method in Science in India Through History, with Special Reference to Biology

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INTRODUCTION

There are two ingredients of this presentation: scientific temper and history. The importance of looking at history does not need to be emphasised at this meeting, but we must explain as to why we have chosen to talk on scientific temper in the perspective of history as this is not commonly done by historians.

We believe that one of the major objectives of studying history is to help in providing a sound basis for development. All development takes place against the background of history. Scientific temper is an essential tool for development, be it individual or collective development at various levels—at the level of the community, of the state, of the country, of the group to which one might belong, or at the level of the whole world.

It does not need much argument to recognise that, for individual development, an understanding of the environment and its challenges and of the rules that govern natural phenomena or social behaviour, ability to evaluate and make judgements that would stand the test of the time, and ability to receive and assimilate information and convert it into knowledge and then into wisdom, are important. Education, the environment at home, social interactions and experience, and logical reasoning, play an important role in acquisition of the above-mentioned understanding and abilities. The scientific method plays a crucial role in this process by providing a framework for understanding the environment and its challenges and the rules of

natural and social phenomena, for evaluating and arriving at opinions and decisions that would stand the test of time, and for logical reasoning.

For collective development, one needs to delineate precisely the goals—both short-term and long-term. The scientific method is an important tool for assessment of the merit of such goals and to ensure that they are achievable within the available means. It is crucial to define strategies for using our assets and containing our liabilities to the maximum possible extent, in real time and on a continuing basis, for achieving the desired goals.

The history of the last 500 years or so clearly shows that whichever country or society followed the scientific approach—knowingly or unknowingly—succeeded and whichever didn't, had to pay a heavy penalty. In our own case, we did succeed after 1947 but not as much as we should have. The basis of our success has been our commitment to science and the scientific method as stated in the Scientific Policy Resolution of 1958, and as has been clear from the policies of our Prime Ministers Jawaharlal Nehru and Indira Gandhi. The reason for our failures has been that we have not been committed enough to the scientific method, outlook or approach. Even our planning process has been devoid of such an approach. This point has been discussed in more detail in the Statement on Scientific Temper that was brought out in 1981 by a group of leading intellectuals of the country, and published by the Nehru Centre, Bombay.

Much has been written about the development of science and technology in ancient, medieval, and modern India. In view of the above-mentioned relationship between scientific temper and development, and the well-established role of science and technology in development, it would be relevant to ask about the extent to which scientific temper existed, developed and was used, consciously or subconsciously, in ancient and medieval India, say, till the end of the last century.

We shall first state what scientific temper is and then go on to talk briefly about the scientific method and the attributes of knowledge obtained through the application of this method. We shall then discuss the extent to which scientific method was practiced, and the attributes of knowledge gained through the application of the scientific method recognised, during our scientific history with special reference to biology.

WHAT IS SCIENTIFIC TEMPER?

In our perception, scientific temper implies the following:

- (a) An understanding of the scientific method.

- (b) An understanding of the attributes of knowledge gained by the application of the scientific method.
- (c) Recognition that this knowledge would be the closest approximation to truth at a given time.
- (d) Rejection of what is totally incompatible with such knowledge *and* cannot be indisputably established by using the scientific approach or method.
- (e) Using the scientific method or approach in our everyday life.

SCIENTIFIC METHOD

Science is far more than just physics, chemistry, biology, astronomy and mathematics, or increasing agricultural or industrial production. It is a question of ideas and a way of thinking; it is a culture and a philosophy of life, a philosophy which allows us to pursue truth without any prejudgement. What, then, is this attitude of mind, this culture and this philosophy of life? It turns out that all these (and other) concomitants and attributes of science emanate primarily from the method that science uses to acquire knowledge.

There are four distinct steps in the method of science: the framing of the question, the framing of a hypothesis, the doing of an experiment, and arriving at the answer which may be a fact or a generalization in the form of a theory or law. At each step in this sequence and in going from one step to the next, we use existing knowledge and logical reasoning.

The *question* in science arises out of careful observation or careful analysis of existing knowledge; there is no third origin of a question! In fact, if you have framed your question properly, you are already on your way to finding the answer. What, then, is a well-framed question? A well-framed question is one for an answer to which means are available within the framework of the method of science. Such a question should lead to a hypothesis which can then be tested by an experiment. Let us take an example.

Out of the million species that inhabit our earth, nearly seven hundred thousand, i.e. some 70 per cent of them (all insects), have six legs—indeed, a remarkable observation, having many implications. Well-framed questions arising out of this observation would be: How did all the seven hundred thousand or so species come to have six legs? Do these species have other common features? Could they have originated in nature from a common ancestor? These are well-framed questions. The more carefully we observe, the better framed our question would be.

The second step, the *hypothesis*, is an answer we may consider possible. The single most important attribute of a good hypothesis—a scientific

hypothesis—is that it must be testable. A testable hypothesis is one which can be tested by an experiment or on the basis of which a testable prediction can be made. For example, a commonplace observation is that objects, if left unsupported in space on earth, will fall to the ground. One can make many untestable hypotheses to explain this phenomenon. One such hypothesis would be: they fall to the ground because a particular friend of yours wills them to do so. Another would be: they fall to the ground because God desires it that way. None of these hypotheses is testable. Therefore, they are not scientific. On the other hand, if you make the hypothesis that an object unsupported in space on earth falls to the ground because there exists a force of attraction between the object and the earth, you can test the hypothesis. In fact, it was starting with such a hypothesis that Newton arrived at his famous law of gravitation.

The third step in the method of science is the *experiment*. The experiment must have one of the following two objectives: either to find an answer to a question, or to prove or disprove a hypothesis. An experiment which does not attempt to do one of these is unlikely to be a good experiment. To do an experiment, one must make an inventory of all the steps in the experiment, collect all the material one needs, and carry out all the steps with the utmost possible care. *More* importantly, one must record all the observations made immediately and meticulously, paying attention to the smallest details. And *most* importantly, one must record everything—expected or unexpected—whether one wished it to be so or not to be so. It is in the doing of an experiment in this manner that the values of objectivity, lack of bias and the exercise of care in what one does, come into existence in science. An unexpected observation could lead to an important discovery. We may recall that penicillin was discovered by Alexander Fleming because of an entirely unexpected observation he made while trying to test quite a different hypothesis.

The last step in the method of science is the *answer*. The answer generally takes one of two possible forms. It could either be a scientific fact of limited applicability, or a generalization of wide applicability.

When the question is simple (such as, 'What is the density of the paper this is printed on, or what is its chemical composition?'), the use of scientific method generates information which at that time would be the closest approximation to truth, provided the method has been appropriately used and has taken into account the relevant knowledge available at that time.

In going from one step to the other in the scientific method, one uses logical reasoning and brings to command all of one's past experience and knowledge. In fact, knowledge is a consequence of collation of bits of

information obtained through the use of the scientific method. Many tools are used in this collation; some of these tools are: drawing of inferences using logical reasoning, classification, analysis, intrapolation and extrapolation.

We must also recognise that knowledge—which can be generally defined reasonably precisely if it has been acquired by using the scientific method—is not equivalent to wisdom which is far more difficult to define and would seem to consist of many more intangibles than knowledge. Experience and logical reasoning allow one to convert knowledge into wisdom which leads one to take decisions that would stand the test of time, on the basis of knowledge or information that is not total or complete. Thus, the process of converting knowledge into wisdom involves intrapolation, extrapolation, imagination, analysis of linkages and the ability to take a global view (this list is surely not complete!).

ATTRIBUTES OF KNOWLEDGE GAINED THROUGH THE APPLICATION OF THE SCIENTIFIC METHOD

The Right to Question

All knowledge arrived at by the use of the scientific method is a consequence of questioning. One of the most important attributes of science is, therefore, the right to question. Knowledge advances and science progresses because people exercise their right to question. However, to question existing knowledge (a fact, theory or law) without any rational basis or reason is as unscientific as never to question at all. The reasons for questioning may be a flaw found in an earlier experiment; a known observation which was earlier fact, theory or law; an alternative explanation found for the evidence on which the earlier fact, theory or law was based; or new evidence which is incompatible with the existing fact, theory or law. Therefore, science puts a constraint on the freedom to question while making the right to question a 'fundamental' right. Let us take two examples, one medieval and the other, modern.

Five hundred years ago, it was universally believed that earth was the centre of the universe and the sun and the planets revolved around it. Copernicus (1473–1543) questioned this belief. His questioning satisfied the criteria stated above. He used the method of science and his creative ability to show that his doubt was justified and that the age-old belief was wrong.

It has been and still is (as school textbooks of geography will show),

a common belief that there is one and only one point on the surface of the earth from where if you travel one mile south, then one mile east (or west) and, finally, one mile north, you would reach where you started. This point is obviously the North pole. A few decades ago, someone questioned this belief, and came out with the interesting finding that there are infinite number of points, lying on a series of loci from where one could do exactly the same thing: go one mile south, one mile east and one mile north, and come back to where one started! This is a remarkable example of how science progresses because people exercise their right to question.

Science has No High Priests who cannot be Questioned

Another attribute of science is that it has no true high priests. No scientist—and a scientist is one who uses the scientific method to generate knowledge—can insist that whatever he says must be accepted without questioning, that is, entirely on the basis of faith in the person. In fact, there has probably never been a scientist, including the most eminent ones, who has not been questioned and shown to be wrong some time or the other. Science, therefore, does not accept the existence of godmen, that is, men (or women) who believe they have special powers that cannot be understood by other men, and whose statements and actions must, therefore, be accepted by others without questioning. Science is, therefore, democratic, non-exploitative and non-dogmatic.

There are no Know-alls in Science

Scientific knowledge never claims to be complete—that is, science does not claim to provide immediate answers to every legitimate question that can be asked at any given time. For example, we do not know yet what the mechanism of memory is (that is, how our brain stores, collates and recalls information), what the origin of the universe is, and what the ultimate fundamental particles are of which the entire matter in the universe is composed.

A scientist can say without any feeling of guilt or shame, 'I do not know'. What science considers undesirable is not the lack of knowledge, but the lack of desire to learn. And what goes entirely against the grain of science is the acceptance of answers that are incompatible with knowledge acquired through the method of science.

Scientific Truths are Truths by Consensus

Knowledge acquired through the application of the method of science represent truths arrived at by consensus based on the method of science. The consensus has to be reached among people who are knowledgeable in the area concerned and who form their opinion by using the method of science. The agreed opinion must be arrived at after such individuals have either verified the result personally, or satisfied themselves adequately about the validity of the experiments and of the logic which led to the particular truth. The greater the above consensus and the greater the evidence in favour of the scientific truth (fact, theory or law), the more rigid must be the proof or the evidence which will allow any modification of the truth to be accepted by the scientists, and the lesser will be the chance that the new evidence against the truth will stand a close scrutiny by them.

As time passes and the sum total of knowledge in the particular field increases, the chances that the initial agreement of opinion will prove to be wrong, diminish. This is the test of time in science. Therefore, science is democratic, but not in a trivial sense. It does not allow one to change his opinion at the whims and fancies of a few.

An important objective of scientific training should be to enable one to evaluate evidence against an accepted and established scientific fact, theory or law, from the point of view of the probability of the evidence being true. It is this aspect of science which gives the method of science a built-in corrective. The corrective is provided through (a) the right to question, and (b) the requirement for a consensus.

HOW DOES SCIENCE PROGRESS?

In science, at a given time, we accept a fact or a theory or a law when:

- (1) all the observations made and experiments done until that time support the fact or theory;
- (2) the new theory satisfactorily explains all that was explained by the old theory.
- (3) no new experiments can be conceived at that time the results of which may not support the theory; and
- (4) all predictions made on the basis of the theory up to that time have turned out to be right.

Then, and then alone, is a theory in science accepted.

An existing fact or theory gives way to a new fact or theory when the following criteria are met:

- (1) New experimental evidence is obtained which is not in conformity with the existing fact or theory.
- (2) The new theory satisfactorily explains all that was explained by the earlier theory.
- (3) Predictions can be made on the basis of the new fact or theory which could not have been made on the basis of the earlier fact or theory.
- (4) Some of these predictions have been tested and every tested prediction has turned out to be right.

In fact, discovery in science often disproves an earlier scientific belief, that is, a part or whole of an existing scientific fact, theory or law. For example, at least two Nobel prizes were awarded for discoveries which were later partially disproved.

Science versus Supernatural

Scientific knowledge contradicts the existence of supernatural and of miracles. One often witnesses or hears about events which, in the opinion of many people, can have only a supernatural explanation, that is, an explanation outside the scope of the method of science. In reality, all such events do have a scientific explanation, often simple and ingenious! If someone produces a rabbit out of a hat, or a watch out of 'nowhere', he is engaged in trickery. All magic is trickery, with relatively simple scientific explanations.

Science, therefore, does not seek an explanation of the unknown in terms of another unknown. When a scientist does not know the answer to a question, he says, 'I do not know'. He does not accept an 'unscientific' answer, that is, an answer which is incompatible with the method of science. He tries to find out if a scientific answer already exists. If no such answer exists, he uses the method of science to obtain an answer. His basic premise always is that, if the question is unanswerable, the answer can be found only through the method of science.

Predictability

A scientific fact, theory or law—that is, scientific knowledge—allows one to make testable predictions. For example, the Russian chemist, Mendeleev, predicted in 1869 the existence of several elements such as gallium, scandium and germanium, long before they were discovered, and assigned to them their right places in his periodic table. Darwin and other evolutionary

biologists predicted the existence of certain species, such as *Latimeria* (a fish), *Pithecanthropus erectus* (the 'erect ape man') and *Oreopithecus* (another ancestor of man), much before their discovery. In physics, the existence of the fundamental particles, omega minus and neutrino, was predicted beforehand. In astronomy, the planets Neptune and Pluto would probably never have been discovered if astronomers had not *looked for them* following the prediction of their existence.

Scientific Observations are Verifiable and Repeatable

They do not depend on the whims and fancies of individuals. Thus, a time reaction set for 19 ± 1 seconds, will take 19 ± 1 seconds—no more and no less—irrespective of: (i) who carries out the reaction (a child, a man or a woman—Indian, Chinese, African or European); (ii) what you may personally like to happen; (iii) the place where the experiment is done; (iv) the time of the day, month or year when the experiment is done.

Science is Truly International

There is one, and only one, science. Scientists all over the world use the same method, the method of science, employ the same techniques, use the same materials, publish in the same journals, are increasingly beginning to use the same language (that is, English), and form a truly international community in which the professional links are at least as strong, if not stronger, than other links.

Science Refutes Religious Dogma that Distinguishes One Religion from the Other

This discussion would be incomplete without comparing—or contrasting—scientific knowledge and religious beliefs. A comparison of science with religion (the term religion, which is used here, refers to religious dogmas that are responsible for the identity of a religion, and not the value system of religions which is essentially the same for all religions and is in concurrence with science) is necessary for the following reasons:

- (a) Religion has attempted to answer the same questions as science has.
- (b) Explanations provided by religion are usually older than those provided by science.
- (c) Through History Science became a competitor to religion and

often came into direct conflict with religion. However, whenever such a conflict arose, the explanation provided by science through the use of the method of science was always found to be correct and was eventually accepted.

- (d) Religion has often hindered the progress of science—that is, of knowledge—and persecuted scientists.

All new knowledge in science must be consistent with known and established observations. Science progresses through modification of a part of the existing knowledge and not by replacement of the entire body of knowledge. The growth of scientific knowledge is a continuous process; science is, therefore, evolutionary. Science takes one forward. For the followers of science, the more modern the text the better it is. The scientists of the time matter most in science at a given time. For the followers of science the events of today and the likely events of tomorrow are the events of greatest concern. The techniques used in science keep on improving with time, and the impetus for improvement comes from within the framework of the method of science.

Contrast the above attributes of science with the following attributes of religion. Religious dogmas, including the so-called miracles (for example, the materialization of objects by a wave of hand), are often inconsistent with known and established observations. A religion once founded continues substantially unchanged. Religious texts, on which the followers of religion depend, are generally ancient. The founders of the religion who lived in the remote past, matter most in religion at any time. For the followers of religion, religious events of the past are the events of greatest concern. Religious customs and practices do not basically change with time. Whatever changes are brought about are due to forces external to religion, such as science itself.

What is inspiring in science is not what had happened in the past, but what is happening now or what may happen in the future. In religion, by contrast, inspiration comes almost entirely from events of the past. There are many religions and they differ from one another in many respects. Activities of a religion are carried out in isolation of other religions, people from other religions being often, prohibited from participating in it. There is little or no communication among various religions and, therefore, no common language. Religious practices differ enormously—often fundamentally—from religion to religion; they divide people. Science, on the other hand, is unitary, open and truly international, and helps unite people.

SCIENTIFIC METHOD IN OUR SCIENCE HISTORY

In the discussion that now follows, we would give examples, mostly from biology with which we are more familiar. (It would be interesting to determine whether or not what we say here about biology would also be applicable to other sciences, specially astronomy and chemistry that developed substantially in ancient and medieval India.)

In the scientific method, the question that the individual wishes to answer, arises out of careful observation or a careful analysis of the existing data. We have had a superb tradition of making careful observations and recording them accurately: our ancestors were indeed compulsive observers. For example, detailed knowledge of various internal and external organs of the body and its various systems was acquired during the Vedic period. In *Atharvavedā*, there are references even to Fallopian tubes and to the relationship between testicles and semen. We were aware of not only bones but also cartilages and ligaments. In the *Caraka Saṃhitā* (believed to have been put together somewhere between fourth century BC and fourth century AD, probably around AD 100) the total number of bones in the human body has been stated to be 360. As we know the total number of bones in the human body to be 206 today, the chances are that all of them had been identified by Caraka's time.

Suśruta's description, even before Caraka, of the anatomy of the human body, within the limitations of the human eye, is breathtakingly comprehensive and analytical. The basic difference between vertebrates and invertebrates was clearly recognised: 'some beings stand mainly with the support of skeleton and others with muscles'.

Parāśara (~ first century BC to AD first century) gave the details of the internal structure of a leaf. His description refers to innumerable small compartments, cell sap and possibly cell wall.

The *Bṛhadāraṇyakopaniṣad* (~ 1000–600 BC) compared the human being with a tree as follows: 'A man is indeed a mighty tree; his hairs are its leaves and his skin is its outer bark. The blood flows (from the skin) of the man, so does the sap (from the skin) of the tree. Thus blood flows from a wounded man in the same manner as the sap from a tree when it is chopped. Flesh within corresponds to the inner bark; his nerves are as tough as the inner fibres of the tree; his bones lie behind his flesh as the wood lies behind the soft tissue. The marrow of the human bone resembles the pith of the tree.' Surely, there is an element of both realism and poetry in these analogies! Suśruta, too, gave a more or less detailed account of different parts of a

plant, with a tendency to compare the plant parts with those of the human body.

Classification of plants and animals into manageable categories came naturally to our ancestors. Some 740 plants and over 250 animals seem to be referred to in our ancient literature; they were classified in many different ways, for example, on the basis of their medicinal property, domestic utility, or morphological features. The first attempt to classify animals in some rational way is found in the *Chāndogya Upaniṣad*, where classification was based on their mode of origin and development. In this classification, there was a group comprising of organisms that were born out of 'heat and moisture of the earth', such as stinging gnats, mosquitoes, lice, flies and bugs. It is interesting that all animals that were small and apparently caused some damage or discomfort, were thought to arise spontaneously, out of the scum of the earth! It was only in the later half of the last century that the theory of spontaneous generation was finally buried by Louis Pasteur, so our ancestors did not do badly at all!

The most elaborate classification of plants was by Parāśara who based it largely on morphological considerations such as floral characteristics. He classified plants into families some of which clearly represent families of today, for example, Leguminosae, Cruciferae, Cucurbitaceae, Kapucynacea and Compositae. The tragedy is that such classification was not improved upon subsequently.

However, the observations our ancestors of the ancient period made, rarely seem to have led to precise questions which would allow the farming of a hypothesis and testing of the hypothesis through means such as an experiment. This stands out in contrast to the development of what is today called 'Western science' in which framing of a question has been extremely important. Thus, Newton wouldn't have discovered his laws of gravity if he hadn't asked the question as to why objects left unsupported in space fall on the ground—a question based on commonplace observations.

In today's science, often, an important question relates to the resolution of an apparent paradox. It would be interesting to look at the history of ancient and medieval Indian biology from this point of view—that is, to determine if questions were asked specifically to resolve certain paradoxes. We have not made such an attempt yet.

As we have already mentioned, questions in science also arise from analysis of the existing information. Such analysis often implies a collation of information from various sources in different areas obtained by different people at different times. It was such an analysis that led to the discovery,

for example, of reverse transcriptase (an enzyme contained in certain viruses and allows the synthesis of DNA from RNA; a Nobel prize was awarded for the discovery of this enzyme which has played a crucial role in genetic engineering). Similarly, our current views on the predictability of monsoon taking into account as distant an element as the El-Nino current of South America, depend on a similar analysis of data from a vast variety of sources. In our ancient and medieval biology, we do not seem to have many (any?) cases of interesting questions being asked following analysis of existing data or information. In fact, in our opinion, if our ancestors had this capacity, the course of the development of biology in India would have been different. Even though Parāśara classified plants into families, some of which clearly represent families of today, the relationship between the various classes was not analysed. If this had been done, a more systematic classification would have almost certainly emerged many centuries ahead of Linnaeus. This analysis would have required recognition of the importance of dealing with many parameters at the time of classification.

Coming to the second step in the scientific method, the framing of a hypothesis; the history of our ancient and medieval biology is replete with hypotheses. Unfortunately, these hypotheses did not have a base in a specific question which, in turn, would have been based on careful observation or analysis. These hypotheses were essentially statements, very often without any scientific basis; they could not be considered as axioms because they were not self-evident. These hypotheses, even though not having any real or solid foundation from the point of view of today's science, nevertheless seemed to have served as a base for putting up large superstructures on them where, again, each statement had to be accepted as such, without questioning. The entire theory of Āyurveda is based on such statements, hypotheses or superstructures.

We give below examples of some such hypotheses from our ancient biological literature. An important criterion of a scientific hypothesis that it should be possible to design experiments that would disprove it just as it should be possible to design experiments that would prove it. These criteria are not satisfied by any of the following statements which are not more than bad hypotheses for they have not been proven to be true.

- (a) Suśruta in his treatise has given a remarkable description of the foetus at various stages of development. He has also prescribed the care that needs to be taken during pregnancy. All this has been found to be fairly accurate. Yet, the same Suśruta attributes the reasons for congenital defects that, for example, dwarfs and hunchbacks suffer from, to the fact that the mother's desires during

pregnancy were left ungratified or repressed. There were several other speculations about cause and effect during pregnancy that we know today are not true. Both Caraka and Suśruta also believed that the fertilised ovum (or the foetus) was developed by palingenesis and not by epigenesis. In other words, all the organs were potentially present in miniature form in the fertilised ovum or the seed, and unfolded in a certain order during the growth of the foetus. Even Śaṅkara shared this view. We *now* know that this is not true.

- (b) Caraka and Suśruta believed that diseases were caused by a disturbance in the equilibrium of the three Ayurvedic humors, and that this disturbance was often a *direct* cause of the disease. They also recognised several remote causes, both external and internal, for example, entry of toxic materials from outside, errors of living, natural decay from old age, and climate or weather, that could play a role in the manifestation of disease. While they were right about the remote causes, their above-mentioned hypothesis about the direct causes of disease is totally untenable.
- (c) There is a mention in *Mahābhārata* that plants are sensitive to heat, cold, sound of thunder, and odours, and experience pleasure and pain. While one can substantiate the fact that plants are temperature-sensitive, and one could perhaps stretch one's imagination to include odours by thinking of the possibility that poisonous gases could have a deleterious effect on plants, current scientific evidence does not substantiate the suggested sensitivity of plants to the sound of thunder (or to music to which claims were made subsequently), or their capacity to experience pleasure or pain as we understand these feelings.
- (d) It is stated that children born with the 'best factors' available are destined to be handsome, virtuous, long-lived, generous, beautiful and responsible in their conduct. While this hypothesis does imply recognition of hereditary factors, it hardly takes into account the influence of environmental factors in the manifestation of genetic abilities.
- (e) In *Agnipurāṇa*, it is stated that the sex of the child is determined by the position of the foetus: this is not true. Suśruta on the one hand has given a remarkably accurate description of the safe and the unsafe periods in a woman's menstrual cycle, but he has gone on to make the erroneous hypothesis that the child is male if conceived on even days and female if conceived on odd days

beginning from the day of the cycle. He also says that sex is determined by the strength of the sperm or the egg; thus the progeny is male if the sperm is stronger and female if the egg is stronger; when the strength of both the sperm and the egg match, the offspring is supposed to be a hermaphrodite.

Coming to experiments, the only area where there seems to be substantial evidence of experimentation is surgery, and that is, perhaps, the reason why surgery has been the most illustrious branch of Indian medicine—perhaps, one of the most illustrious in all of ancient or medieval Indian science. Thus, fifteen different methods were described by Suśruta for the extraction of a foreign body loosely or firmly embedded in the tissues, a magnet being used for iron particles. And, Indian doctors in the ancient period achieved such perfection in plastic surgery that European scientists of the nineteenth-century borrowed several methods from them. Suśruta also discovered the art of cataract-couching which was unknown to ancient Greece and Egypt. Limbs were amputated, abdominal operations performed, fractures set, dislocations, hernia and ruptures reduced and hemorrhoids removed—all with an amazing rate of success. The earliest of rhinoplasties appear to have been performed in India in 1600 BC—the practical rhinoplasty operation spread from India through Arabia and Persia, to Egypt and from there to Italy.

Indeed, the basis of these successes was the fact that the dissection of dead bodies was considered indispensable for a successful student of surgery and that such bodies were made available for various experiments. It would be interesting to analyse the reasons as to why the experimental method that succeeded so well in the development of surgery in ancient India, was not used in other areas of biology with the same rigour.

We have mentioned that the use of scientific method often generates information, and to convert information into knowledge one resorts to various approaches such as collation of information, drawing of inferences, trial and error, classification, etc. Our ancestors certainly knew how to convert information into knowledge by using all these techniques. We must, however, immediately add that none of the techniques that we have mentioned for conversion of information into knowledge, is fool-proof. The validity of the knowledge obtained by these techniques has, to be therefore, continuously checked and rechecked by further experimentation and questioning as new techniques and new evidence becomes available. This is unfortunately where we failed. Thus, we have instances of important conclusions arrived at by using the above techniques that have stood the test of time, just as we have instances to the contrary. We would now like to give examples of both.

EXAMPLES WHERE CORRECT CONCLUSIONS WERE ARRIVED
AT THROUGH COLLATION OF INFORMATION,
DRAWING OF INFERENCES, CLASSIFICATION OF
INFORMATION, ANALYSIS, EXTRAPOLATION, INTRAPOLATION,
AND TRIAL AND ERROR

Our ancestors had rightly concluded that life, including all biological processes within us, is dependent on the generation of heat. Our ancient-medieval literature states: 'This body heat comes out of food which also nourishes and maintains the organism through its metabolic transformations. Ingested food and drink pass into the stomach and become minutely dispersed by the digestive fluid present there; their assimilable contents then turn into a sweet, frothy, mucus-like fluid. This process of digestion, carried out by *agni* (digestive fire), continues until the fluid becomes acid, issues out of stomach and excites the secretion of thin bile. At this stage it is an assimilable, nutritive fluid known as *rasa*, which is pumped by the heart through twenty-four major channels and permeates the entire system. *Rasa* constantly moistens, nourishes, maintains and irrigates the organism by processes which were not completely understood'. Mostly today's state-of-art, and incorrect only in detail!

The conclusions arrived at in regard to the reproductive process, both in animals and in plants, in ancient India were truly impressive. Although there does not appear to be enough evidence of the knowledge of sexuality in plants in the Harappan culture, sexual reproduction in higher plants as well as in higher animals is mentioned in the pre-Buddhistic *Kathopanishad* as being similar. Seeds and flowers were believed to be produced by the cooperation or union of different sexes. Pollen was believed by Amara to be analogous to the female menstrual fluid. In the *Brāhmanās*, a constituent of the Vedas, there are many references to conception and to child-birth. As has been already mentioned, the testicles were recognised as being responsible for the production of semen. It was also recognised that the semen should get amalgamated with the contribution of the woman in her womb; unless this happened, pregnancy could not be established.

Garbhopanishad gives a detailed and fascinating description of the day-to-day and monthly development of the human embryo through its various stages, from conception to delivery. Suśruta gave the best time for conception from the fourth to the twelfth day from the date of beginning of the menstrual flow: precisely what is recommended for a 22-day menstrual cycle today! Imagine the amount of information he must have collected to arrive at this conclusion and that too how, and in what kind of a culture! (May be our today's perceptions of that culture are inadequate.)

The role of the umbilical cord and the navel was amazingly well recognised. 'The *dhamanis* in the foetus take their rise from the umbilical cord, thus bringing nourishment from the mother', and the navel in the foetus was rightly stated to be the source and origin of the entire vascular system. To continue the quotation, 'The embryo is held at the navel. It grows without taking food, that is, there is no effort made on the part of the embryo to take food and no food is specially served to it. The food in its final form, is assimilated automatically and directly into the system of the embryo. The child is nourished of its own accord as it were. The mother is not conscious of the nourishment given to the young one below her heart.' Could it have been said better?

The animal body was recognised to be sustained and nourished by blood which was 'conveyed through a large number of channels to every part of the body'. Existence of capillaries was recognised in numbers that were impossible to count. It was stated that urine is formed by draining of the waste or refuse matter in the body by water. The water content of the urine was correctly concluded as derived from the drinking water and from the moisture of the food taken in. Urine was, therefore, correctly thought of as a body fluid which served to eliminate waste metabolic products not required by our body.

The growth of a plant was recognised to depend on soil, water and season. It was recognised that light had something to do with the process of manufacture of food by plants and storage of energy in their body.

Caraka made another highly perceptive and logical statement when he said that diagnosis of a disease should depend on (i) theoretical knowledge of the possible causes and symptoms of diseases, (ii) meticulous observation of the patient's symptoms and complaints, and (iii) inferences based on previous experience.

One of the most remarkable deductions made in the history of Indian medicine was in regard to small pox. In fact, the impression that India was in a state of rapid decline in the late eighteenth century, is certainly argued against by the fact that inoculation against small pox was practised in the subcontinent at this time, and long before it became generally acceptable in Europe. It was unknown in Europe till 1720, when the wife of the then British ambassador in Turkey, having got her children successfully inoculated, advocated its introduction into Britain.

The farmers of the Vedic period were aware of the possibility of improving the fertility of the soil by rotation of crops—a concept that developed in the West very much later. Rice was grown in summer and pulses

in winter. References to rotation appear in *Rgveda* and *Yajurveda*. Thus rye-grass and clover were grown with wheat, barley or oats, and beans with peas.

The ancient cultivators knew how to select the seeds and what to sow when and where; they recognised the need of replenishing the nutrients of the soil by manures. The later Vedic agricultural farmers seemed to be fully conversant with the use of *organic* matter such as appropriately processed cow-dung, bones, blood, and plant products such as the straws of barley. The manures are today known to contain nitrogen, phosphorous and potassium.

From 300 to 200 BC onwards, the early stages of the germination of seeds and the factors governing germination (such as proper season, good soil, water, vitality of the seeds, and proper care) were clearly recognised. Kaṭilya's *Arthaśāstra* mentions the effect of temperature on germination; it gave specific conditions required for germination of different kinds of seeds.

We had learned how to determine the age of animals from sequential changes in their teeth, and we knew how to train animals and to exercise control over them. Cattle breeding appears to have been one of the important aspects of animal husbandry practice in ancient India.

EXAMPLES OF INCORRECT CONCLUSIONS ARRIVED AT BY USING THE SAME TECHNIQUES AS MENTIONED ABOVE

- (i) According to Suśruta, the intervention of a superior agent was absolutely essential for the origin of life on our planet. We today understand the basic sequence of events that led to the origin of life on our planet some 12 to 15 billion years ago and in that sequence there is no place for any superior agent.
- (ii) In the Upaniṣads, evolution on earth is explained as follows: ether sprang from earth, air from ether, fire from air, water from fire, earth from water, herbs from earth, food from herbs, seed from food, and men from seed. This, of course, is a far cry from what we know today about evolution.
- (iii) Our ancient postulate that the five physical elements—ether, wind, water, fire and earth—constitute the human body is, of course, totally untenable.
- (iv) The theory of spontaneous generation of lower forms of life such as maggots and worms, is deeply rooted in our ancient culture. Pasteur disproved this theory dramatically in the last century.
- (v) The food that we eat was stated to contain five classes of nutri-

ents: the earth-compounds, the aqueous-compounds, the *tejas* compounds, the *vāyu*-compounds and the *ākāśa*-compounds. The earth-compounds were postulated to form the hard matter of the body, the *tejas*-compounds to provide the metabolic heat, the *vāyu*-compounds to serve as source of the motor-force in the organism, the aqueous-compounds to furnish the watery parts of the body, and the *ākāśa*-compounds to contribute to the fine etheric essence that was considered to be the vehicle of conscious life. These concepts do not relate at all to our knowledge of nutrition as of today.

- (vi) In the *Brāhmanas*, Caraka says that the offspring derives its softer tissues like skin, flesh, navel, and intestines from the mother, and the harder tissues such as bones, blood vessels, veins, etc. from the father. This erroneous belief, perhaps, satisfied the male ego!
- (vii) It was believed that mother's nutrition could determine the sex of the child. For a male child, ghee and milk were recommended, and for a female child, oil and beans. Another example of male chauvinism!
- (viii) In the *Agniṣṭurāṇa*, heart was considered to be the seat of consciousness and the centre of our nervous system. It was only in the Tantric writings between the eighth and the fourteenth century AD that the seat of consciousness was transferred from the heart to the brain. It was even proposed that one pair of *dhamanis* going from the heart to the head was engaged in conducting sensory currents pertaining to sound, smell and taste. Perhaps, this was so because all the sensory perception was lost with the stopping of the beating of the heart. Today, we know that in a clinically alive person, the heart could still be beating, in spite of all the sensory perceptions being lost. Suśruta also stated the precise location of the soul in the body! The soul or *jīva* was supposed to reside in the upper cerebrum but could traverse the whole cerebrospinal axis up and down. There is no place in modern biology for such a concept of 'soul'.
- (ix) The Indian traditional medicine contained in the *Āyurveda*, arose from the notion that a body remained healthy if there was equilibrium between the three humors, *vāyu*, *pittā* and *kapha*, present in our body. These three humors were stated to govern and activate the entire gamut of biological processes from conception onwards. The description and characteristics of these three

humors in *Suśruta Saṃhitā* does not even remotely correspond to our today's knowledge either about the body or about its functions as of today.

- (x) The beliefs that were codified in our ancient writing, regarding the position of a pimple determining the immediate fate of an individual, make amusing reading. Thus, 'pimples appearing on the hands, fingers and belly, lead to the acquisition of wealth, fortune and grief, respectively; on the navel, to finding food and drink; those beneath the navel, to loss of wealth through theft; on the pelvis, to wealth; on the thighs, to the procurement of a vehicle and a wife; on the knees, to loss on account of enemies; and on the ankles, to trouble while travelling and during confinement.'
- (xi) It seems likely that Manu's belief in the caste system, that led to his systematising the entire system and has been at the base of many of our present-day problems, was deeply rooted in his erroneous perception of the mechanism of transmission of inheritable characters.
- (xii) Our ancient literature is replete with examples of scientifically untenable male chauvinistic statements. Here are translations of two such *ślokas* (note the part in italics):

When (at the time of coitus) the blood (of the woman) exceeds the sperm (of man), a female will be born; when the sperm exceeds the blood, a male; when both are equal, a hermaphrodite. *Hence, one ought to take tonics that increase one's sperm.*

A man ought to have sexual union with his wife when the *Kendras* and the *Trikona* houses are occupied by benefics, when the Moon and the *Lagna* are conjoined with benefics, when malefics are posited in the 3rd, 6th and 11th houses and when there are planetary combination *ensuring the birth of a male.*

DID OUR SCIENTISTS OF YORE RECOGNISE THE
ATTRIBUTES OF SCIENTIFIC KNOWLEDGE?

The Right to Question even the High Priests

Lord Buddha who lived in the fourth-third century BC said:

Believe nothing
Merely because you have been told it
Or because it is traditional
Or because you yourself imagined it

Do not believe what your teacher tells you
 Merely out of respect for the teacher
 But whatever, after due examination and analysis
 You find to be conducive to the good
 The benefit
 The welfare of all beings
 That doctrine believe and cling to
 And take it as your guide. . . .

Yet, the culture of questioning following the norms demanded by the scientific method mentioned above, never really took root in India in the ancient or the medieval period. (Even today, scientific questioning, although far more common than, say, even 50 years ago, has not become a part of our culture and thought process.) One important reason was blind respect for age, position, authority and power, which became a part of our cultural, social and religious traditions. One could ask a question to seek a clarification from one's elder or teacher, or those who were in power or had authority, but one did not question the validity of their statements. In a hierarchical society that ours has always been and continues to be, there were no two people who could establish an equal relationship with one another. Further, the knowledge system in science at least, was based on the concept of 'high priests' who were not to be questioned. This was one of the main reasons for the stagnation of our knowledge and our reluctance to imbibe the advances that occurred elsewhere—specially from the fifteenth century onwards in Europe. Consequently, for example, the Āyurvedic practice of today is based virtually entirely on what was written in ancient texts by the high priests of that time. The concept of high priests who may not be questioned is so deeply ingrained in our culture, with its origin during the Vedic period, that even our present-day society is replete with Godmen who have an immense following, so much so that—may be—one out of every three adults in the country may be today a follower of one or another Godman.

*Scientific Knowledge is Never Complete and there are
 No 'Know-alls' in Science*

One of the most significant deficiencies of our ancient science has been that it has purported to be complete with answers provided to all possible questions. It is for this reason that many in the country believe even today that our ancient literature contains answers to every question that one may ask today, and that everything that is known today—from aeroplanes to nuclear devices—was known to our ancestors. Āyurveda is thus presented

as a complete medical system with a cure for virtually everything. This view is supported by the fact that, barring minor nuances of interpretation, basically the Āyurvedic repertoire of today—both in regard to knowledge and practice—is probably not very different from what it was more than 2000 years ago. This stands out in contradiction to one of the important attributes of scientific knowledge—that it is never complete.

Scientific Truths are Truths by Consensus

A large number of individuals take part—individually and collectively—in the process of discovering scientific truths, their consolidation and subsequent acceptance. The consensus is arrived at amongst equals with each one having the right to verify and challenge everyone else. Of course, everyone who takes part in this process and whose opinion counts, has to be appropriately trained and committed to the use of the scientific method and acceptance of the attributes of knowledge gained through this method. It is obvious that for arriving at a consensus that would be likely to stand the test of time, there has to be much discussion, debate and questioning. The *gurukul* tradition and the *guru-śiṣya* relationship that was at the base of transmission of knowledge in our ancient culture, did not have the ambience to create equals who could question each other and carry out a discussion of the kind mentioned above. Consequently, our ancient and medieval science was not a result of consensus but a collection of pronouncements made, no doubt, by highly knowledgeable people. Truths do not appear to have been established by verification, discussion and doubting, and the resolution of doubts did not take place by discussion within a framework of knowledge, logic and reasoning.

Science Progresses by Disproving and This Process Follows Certain Rules

It is, indeed, the fact that science progresses by disproving that makes it evolutionary. All the evidence that we have been able to gather in the area of biology suggests that the method of disproving was not used by our ancestors to advance scientific knowledge. In our tradition, if anyone had a new idea, he propagated it for others to accept or reject, without his disproving what was believed to be the truth earlier. We have not come across any instance in which a later scientist had openly criticised someone who came earlier and actually proven him wrong so that the earlier belief was buried forever—just as Dalton's atomic theory is buried forever.

Science Contradicts the Existence of the Supernatural

Belief in the supernatural and related magico-religious practices, was central to all science of the past: astrology to Āyurveda. For example, the belief

in sins, demons and magic as the cause of disease was deep-rooted and widespread in ancient India. It appears that during the *Atharvavedic* period, there existed two main types of healing arts. The first type depended largely upon incantation of magical verses and sacrificial practices to bring about cures. The second type, while also using magical formulae, relied basically on the empirical or rational use of herbs and other medicaments. Thus, herbs were used in combination with spells and diseases were sought to be cured by propitiating the demons: cures that had the authority of Upaniṣads and the *Sūtras* (800–300 BC) behind them. There were specific mantras for particular diseases. Thus, there are mantras addressed to Sūrya to cure heart disease and jaundice. Similarly, there is a mantra to increase the power of sight and to cure certain diseases of the eye. One would not be exaggerating if one says that this is unmitigated nonsense. If the magico-religious elements had been shed, and our ancient system of medicine had confined itself to adhering to and relying upon empirical observations which could then be modified as the database increased, perhaps the evolution of medicine in India and, consequently, around the world, might have taken a different course.

The supremacy of magico-religious medicine during the *Atharvavedic* period is more than evident in their belief in the wonders of an amulet. 'An amulet was looked upon as a weapon, an instrument, which protects the wearer against misfortune and disease.' And there are many hymns in the *Atharvaveda* to be recited at the time of binding an amulet. The material in the amulet depended on the effect that was desired—from curing hereditary diseases to obtaining a male child!

Diseases were believed to be caused by a variety of unverifiable and ill-defined external agents and action—such as the wrath of God, possession by demons and evil spirits, sorcery and the like—which, by definition could never be shown to exist or experimented upon. As time passed, the evil influence of planets and stars also came to be regarded as a cause of disease. And it wasn't all that crude either: specific diseases were believed to be caused by specific demons or spirits. We, of course, do not believe that these ideas can be equated with the causation of different diseases by specific micro-organisms that we know of today!

Science Allows One to Make Testable Predictions

This attribute of science was unquestionably recognised by our scientists of the past—though there is little evidence of this attribute being used to actually advance the frontiers of biology. On the other hand, the predictive

value of Indian astronomy seems to have been its bread and butter and is what gave it a sound footing.

What would be worth investigating in some detail is whether the considerable success that our astronomers had with their predictions was partly responsible for laying the foundations of the unscientific system of astrology.

Scientific Observations are Verifiable and Repeatable

We have no doubt that many of the observations made by our ancestors *that have stood the test of time* and are compatible with today's science, must have been verified by subsequent observers in history. Similarly, many conclusions arrived at by the limited experimentation to which our ancestors resorted as in surgery, or by calculation as in astronomy, must have been verified through subsequent repetition. Therefore, in a way this criterion of scientific knowledge was probably satisfied by at least a part of the knowledge gathered at that time—the part that is valid as of today. However, the important question we must ask is: whether or not verification and repetition with an open and unbiased mind was a part of the methodology of authentication of the scientific knowledge in the past. This would merit a detailed study which we have not yet done. We suspect that this was so but only on a very limited scale. We know that a substantial body of knowledge gathered in the past—specially that which was based on conclusions arrived at on the basis of inadequate observation or experimentation—has not been found to be verifiable and repeatable today. It must have been found to be so by others as well in our past but, perhaps, due to the prevailing social milieu, the person who could not verify or repeat what had been said earlier, thought it wise not to document his failure. He may have merely documented his new idea without reference to the past. We believe there is a strong case for a systematic study of original source material that is available to us today to determine to what extent a reference has been made to all the earlier works and in what context. (Perhaps, such a study has not been done so far.)

Science is International

What we should perhaps say is that *valid* science is international. In fact, international acceptance is today considered an important criterion of validity of scientific theory or idea, observation or experiment. Our astronomy, mathematics, technological processes and later practices such as vaccination, did receive this validation; the same was true of surgery. However, Āyurveda as a system did not receive this validation though the efficacy of

certain drugs which formed a part of the Āyurvedic pharmacopoeia was subsequently confirmed internationally; reserpine would be one example.

International validation is a reciprocal process. We may, therefore, also ask as to what extent did our biologists in particular and scientists in general attempt to validate what had been discovered or claimed elsewhere in the world—at least in geographical areas with which we had regular communication. It is this mutuality of validation that makes one a part of the international structure of science which brings its own rewards. We must also distinguish this process of mutual validation from the indirect influences that one country's science may exercise over another country's—influences which are the consequence of a large number of factors that operate over a period of time. (There is an intangibility about such 'influences' which is not there in the process of scientific validation.) Again, it would be worthwhile to examine our ancient and medieval scientific literature and source material to determine the extent to which our scientists engaged in validation of knowledge gathered elsewhere, and to what extent they were influenced by it, making a distinction between the two processes.

Science Refutes Religious Dogma

We have argued elsewhere in detail that science and religious dogma are incompatible (P.M. Bhargava, 'Does science refute religion?' *Society and Science*, 1981, 4, 42–50). Our science in the ancient and the medieval period does not appear to have refuted religious dogma. On the other hand, it seems to have become subservient to it and even sought the seal of approval of dogmatic and other irrational beliefs that were either an integral part of or were deeply intermeshed with religion. Some examples have already been given.

Other Attributes of Scientific Temper in Our Knowledge of the Yore

We did not recognise the fact that scientific knowledge at any given time is only the closest approximation to truth; we equated it with immutable truth. This tradition continues even today. Therefore, we rejected what was not compatible with it even if it could be independently established by using the scientific approach.

Our daily life was governed by the dictates of religion, custom, convention and tradition, rather than the scientific approach. We accepted science only if it came to us through these other approaches and not as an independent body of verifiable truth.

CONCLUSIONS

It seems to us clear that even though Indian science reached remarkable and commendable peaks in certain areas, the scientific method and the scientific temper as a methodology, approach or way of life, were alien to us. This in itself, perhaps, could not be considered as a major disadvantage. What, we believe, has been a disaster is that the scientific method and the scientific temper continued to remain alien to us even when they became a major force in Western thought, at least from the thirteenth century onwards, specially, with the beginning of the Renaissance in Europe with Leonardo da Vinci. And scientific temper and method continue to remain alien to us even today, more than a century after the introduction of Western science in the country—when other countries with equally strong local traditions in science, such as China, Japan and Vietnam, have recognised their validity.

One may ask why the scientific method did not develop and scientific temper did not take root in India despite the fact that India has had a five thousand year-old tradition of science, unlike Europe with the exception of Greece. We give below some of the possible reasons:

- (1) The above-mentioned tradition itself could have acted as a block to the development of the scientific temper and the acceptance of the scientific method on account of an in-built resistance to change that has characterized all early societies.
- (2) In a hierarchical society, specially one in which knowledge is considered as the confine of a select number of people identified by birth, knowledge becomes a tool of perpetuating vested interests. Under such circumstances, development of a culture of questioning which is an integral part of the scientific method, would pose a serious threat to the continuance of these vested interests.
- (3) Finally, the tradition of experimentation was lacking in our ancient and mediaeval culture—even in Gautama's *Nyāya Śāstra*. Experimentation to test a hypothesis based on observation or analysis of existing information, is the key to all modern scientific inquiry and progress, and an important step in the scientific method. Wherever we did experiments as in relation to surgery, the knowledge gained has stood the test of time.

Education in Ancient India (AD 300–1000): Some Aspects of Theory and Practice

S. SANKARANARAYANAN

Education plays a vital role in every culture and civilization of the world. So it does in the Indian culture and civilization too. The present paper intends to study briefly some aspects of the theory and the practice of education with their background that were in vogue in ancient India, particularly during AD 300–1000. No doubt the readers are aware of the monumental works like *Education in Ancient India* (1st edn, Banaras, 1934), by A.S. Altekar and *Ancient Indian Education—Brahminical and Buddhist* (London, 1947), by R.K. Mookerji on the subject. However, the present paper concentrates on the point not dealt with in those works.

I

'Man is born free and everywhere he is in fetters and consequently he suffers afflictions unendingly', the philosophers point out and sympathise. 'Man should be educated to break off his fetters and win back the freedom he has lost. For fetter, i.e. slavery, is hell and liberty is paradise,' so harangue the teachers and reformers. If man is born free, i.e., if freedom is man's original nature, how has he lost that paradise and landed in the hell of pain? How can he get out of this hell and go back to or regain his freedom, paradise of bliss? Many and varied are the answers to these questions. Indeed, all the cultures and the civilizations of the world present us stories as to how man has theorised about the loss of freedom and how he struggled in

innumerable ways for regaining his paradise of liberty. This is perhaps the shortest summary of the history of cultures and civilizations of the world.

The builders of civilizations, in spite of their mutual differences in details, seem to concur on one point: if by nature man is born unto fetters and also unto miseries thereof, just as sparks are born unto upward flight or fire unto heat, it is impossible to make him otherwise, i.e., to make him free. For, the real nature of a given thing cannot be altered.¹ Indeed, no one has ever taken interest in making sparks fly downward or fire turn cold. But, since the dawn of history, man is found trying to win freedom and bliss back and great sages are also known to have successfully won this freedom. Therefore, it is certain that the real nature of man, i.e., of the soul, is freedom and bliss; somehow, on account of his own ignorance, he has lost that liberty of his and suffers hellish miseries now. Because misery is not his real nature, he can certainly by some *correct means* cut off his hellish fetters of bondage and slavery, get rid of his present miseries, and regain his natural paradise of liberty and bliss. Now that correct means cannot but be correct knowledge. For, this alone is the sure antidote for ignorance, on account of which liberty has been lost.

The fathers of civilizations must have theorised in their respective ways and arrived at the above point. That is why all civilizations, through their respective sublime limbs of religion and philosophy educate man to gain correct knowledge (*tattvajñāna*) and regain his freedom (*mukti*)² and bliss. Because education alone is the means to gain knowledge, it constitutes the most vital, integral part of every civilization. Indeed, no-education means no-civilization.

II

The Indian thinkers of yore found that man has two sides: the inner side, viz., the soul; and the outer one, viz., the cluster or the apparatus of the physical body and senses—by the latter the former seems to come into contact with the objects of outer world. These thinkers also discovered that man is fettered on both these sides of his and hence his miseries are two-fold. The conclusion is: he must be educated properly to unfetter himself on both the sides. Because the correct knowledge, the only means to regain freedom, is entirely personal and inward, one has to unfetter himself.³ No outsider, however mighty and wise he might be, can unfetter another person. What maximum an outsider can help him is only to educate him properly and to impart knowledge pertaining to both the sides of his.

The ancient thinkers of India, therefore, classified knowledge broadly

under two heads: spiritual wisdom (*jñāna*) and temporal wisdom (*viññāna*).⁴ All branches of learning, the final goal of which is to help man in attaining or regaining his internal freedom of soul and bliss, belong to the first category, viz., *jñāna*. The second category *viññāna* comprises all branches of science, the aim of which is to help man in gaining his external freedom by controlling and thwarting the forces that fetter his outer personality and generate miseries.

In other words, the realm of *viññāna* includes all branches of knowledge that intend to enable man to live as a citizen (*nāgarika*), a civilized happy life, free from worldly miseries, even while he, knowingly or unknowingly continues to be in fetters internally. So, the sciences like physics and chemistry, biology and medicine, engineering and technology, economics and political science, fine and performing arts, music and dance, and so on, all fall under the head *viññāna*.

The last mentioned name, i.e., *viññāna* may be conveniently rendered as *wisdom of civilization*. For, the word *civilization* is derived from the Latin *civilis* 'of citizen', and the sciences, we saw above, help man to live a comfortable life of a *nāgarika*, a citizen. On the other hand, the holy scriptures, religion, philosophy, Yoga, devotion to God and other spiritual practices are meant to help man to go up and up in the ladder culminating in total liberation. Hence they all belong to the realm of *jñāna*, a term seems to signify *wisdom of culture*. We know for certain that a burning desire to study, to make an inquiry into Self, and to undertake spiritual practices like *yoga*, *bhakti* etc., is a thing to be assiduously cultivated,⁵ by rising above, or by putting down, the human propensity to live a life of sensuous pleasure. And we know that the word *culture* includes in itself an element of cultivation.

The *Kāthopaniṣad* depicts Naciketas as an ardent seeker of Self, steadfast in his desire for Self-knowledge, i.e., wisdom of culture, and in avoiding the trap set by the god of death, a trap in the form of riches, sensual pleasure, long life etc., coveted by every honourable citizen by means of wisdom of civilization mentioned above. The *Chāndogyaopaniṣad* paints the sage Nārada as a master of all the sciences and wisdom of civilization, and yet, as one helplessly craving Sanatkumāra for the wisdom of culture. Examples from the Purāṇas and literary works of the classical period can also be easily multiplied.

No doubt, in common parlance *culture* and *civilization* are synonyms. But, their respective etymological connotations are different. True, the physical and biological sciences too are not nowadays totally ignoring the spiritual side of human personality, while philosophy, religion etc., too cannot entirely

shut their eyes to material and social side of man. Therefore, it may not be practical to build a water-tight wall between the materiality of civilization and the spirituality of culture. Yet, by the above *jñāna-vijñāna* classification of knowledge the ancient Indians have shown us how to draw a theoretical line between the wisdom of civilization and the wisdom of culture. In fact, this *jñāna-vijñāna* classification is nothing but a re-enunciation of the Upaniṣadic classification of knowledge as *aparā vidyā* and *parā vidyā*, the lower wisdom and the higher wisdom.

III

The Indian concept of four-fold goals of human pursuit (*ṣuṣārtha*) is well-known as a factor that influenced all the religious and philosophical thought and movement particularly of the orthodox camp. Of the four goals, viz., the *Dharma* (performing scrupulously one's own duty as enjoined in the scriptures etc.), *Artha* (acquiring wealth), *Kāma* (enjoying pleasure of senses), and *Mokṣa* (total Liberation), the first three were viewed as a separate group known by the nomenclature *trivarga*. This concept and classification of the goals of man's pursuit had influenced the Indian thought and literature down the ages. That is why the heroes of the poems, romances and epigraphical eulogies are depicted, almost invariably, as pursuers of the *trivarga*. Besides, the doctrine of transmigration of soul and its allied theory of *Karma* are also equally well known as the common bedrock of all the religions and philosophies of India, the only exception being the disbeliever Lokāyata. The close interaction and interplay between these doctrines have been responsible for certain interesting developments in the theory and practice of education during the period of our study.

The soul transmigrates since eternity. The creatures are caught in the continually revolving cycle of birth and death. The nature of one's birth, the condition of one's body, and the pain and pleasure one meets there, all are the inevitable fruits, rather shadows of the *Dhārmic* and *Adhārmic* acts one has committed previously as an occupant of some earlier body. The corollary is: soul alone is permanent and eternal and its real helper in its onward and upward progress is *Dharma* alone. So, if one intends to have a real progress and happiness, one must first take into consideration the betterment of one's own soul, the permanent one and adhere to the principles of *Dharma* alone. Again one should, neither out of fear, nor out of craving for pleasure, give up one's *Dharma*, even for the sake of saving one's own life or gaining *artha* and *kāma*. For, the soul alone is permanent and all the other viz., life,

body, pleasure and pain come, disappear and reappear. In fact, a good life, a healthy body, wealth and pleasure are all nothing but the fruits of *Dharma*.⁶

The above enunciation of the doctrines of *Karma* and transmigration disturbed the delicate balance that had been maintained along the four *Puruṣārthas* mentioned above. The wind started blowing in favour of *Dharma*. It occupied the pedestal of honour much over and above the *Artha* and the *Kāma*. The result was: though the age inherited literature on all the three of the *trivarga*, it fast stopped producing independent treatises on *Artha* and *Kāma*. No doubt, Vātsyāyana's famous *Kāmasūtra* is assigned tentatively to the fourth-fifth century AD; and the Western Gaṅga king Durvinita (c. AD 600) claims to have written a brief commentary (now lost) on the aphorism of Dattaka, a predecessor of Vātsyāyana in the field. Yet, the literature on *Kāma* did not make much headway, as the other branches of learning did. So became the fate of the *Arthaśāstra* literature too. The only notable work on *Artha* during the age is the *Nītisāra* of Kāmandaka (c. AD 700). But, the *Nītivākyaṃṛta* of the Jaina author Somadeva (c. AD 900) is almost a sort of commentary on the *Arthaśāstra* of Kauṭilya. As a result, the *Artha* and *Kāma* slowly acquiesced to remain as subsidiary subjects of the treatises on the *Dharma* and to be the themes, more liberally dealt with in the poems, fables, romances, dramas etc., of the age. The *Śatakatrāya* of Bhartṛhari (c. AD 400) and the Tamil work *Tirukkural* of Tiruvalluvar (c. AD 450)⁷ of the age are perhaps the two exceptions that give due reverence to all the four goals of human pursuit. But, on the whole, the *Dharma* became an unchallenged sovereign of the *trivarga* empire.

IV

Further, the *Dharma Mimāṃsakas*, the champions of *Dharma* tried now to establish the supremacy of *Dharma* even over *Mokṣa*, the fourth *Puruṣārtha*, the goal of spiritual pursuit. A change had already taken place in the history of Indian philosophy in their favour:

In the age of Upaniṣads, the branches of knowledge were known by the Sanskrit name *Vidyā* 'science', a term derived from the root *vid* 'to know'. Somehow this name came to be replaced by another Sanskrit name *Śāstra* 'commandment', a term derived from the root *śās* 'to command'. The authors of the orthodox *darśanasūtras* invariably employ only *śāstra* in the place of the Upaniṣadic *vidyā*, while they use the latter term as a synonym of *tattva-jñāna* 'correct knowledge' or 'knowledge of truth'.

The Mīmāṃsakas took the above change to their advantage. With an aim to achieve the supremacy of *Dharma*, as stated above, they managed first to maintain the non-human origin of the scripture par-excellence, viz., the Vedās (*vedāpauruṣeyatva*) and their self-proven authority and its unquestionability. Proceeding further, they defined *Dharma* as 'one which the scriptural commandments enjoin as a means to attain a desired goal'. They then pointed out that the *śāstra*, the scriptural commandment—just like the king's or master's order—is meant only to generate the one or the other activity in an individual to whom the commandment is meant. So, they formulated the dictum that 'the ultimate purport of the scripture is only to lay down action'.⁸

Basing on these, the *Dharma Mīmāṃsakas* argued that the Upaniṣadic doctrine of the identity of the soul with the Supreme is concerned only with *knowledge* of the items that are already in existence and in this there is no element of *action*. Hence, this needs to be properly connected with *Dhārmic* action viz., the Vedic sacrifice, so that this too may have the status of being a purport of the scripture. So, we are compelled to accept that the said Upaniṣadic identity is a thing to be meditated upon by the person who undertakes the scripture-enjoined *Dhārmic* act of performing the Vedic sacrifice; that the Upaniṣadic doctrine has no independent authority, because the same has to depend on the authority of the *Karmakāṇḍa* doctrine of the Veda; and that we have to necessarily place *Mokṣa*, the fourth *Puruṣārtha* taught in the Vedānta below *Dharma*, the first *Puruṣārtha*, taught in the *Karmakāṇḍa* part of the Veda.

Now, it is left to the genius of Śrī Śaṅkarācārya of the age to fight back against these *Karma Mīmāṃsakas*, to establish the independent authority and supremacy of Vedānta and the *Dharma* of renunciation (*Nivṛttidharma*). The alleged famous debate between Ācārya Maṇḍana and Ācārya Śrī Śaṅkara is only a specimen or a part of the intellectual duel, a mighty tug-of-war in which the philosophers of action and the philosophers of renunciation were actively engaged during the age.

Finally, Śrī Śaṅkara succeeded in establishing the independent authority of the Upaniṣads as a scripture by itself and also in placing his philosophy of renunciation and its *Mokṣa* on a pedestal over and above the philosophy of action and its *Dharma*. In this struggle for supremacy the Ācārya draws strength and support from the Upaniṣads that classifies knowledge under the two heads viz., the lower wisdom and the higher wisdom and tells us in definite terms: the lower is the four Vedas and their accessories and the higher is the one, by means of which the Supreme is

realised and attained.⁹ It deserves to be noted here that the above Upaniṣadic classification of knowledge is the clear forerunner of the *jñāna-vijñāna* classification enunciated by the authors of the classical times we saw earlier.

At the end of the above struggle, the position was totally different: what is taught by the philosophy of action cannot, by itself, break one's internal fetters and give one the total freedom from the cycle of birth and death. On the other hand, if, with no craving for results, one performs his actions (*niṣkāmakarma*) enjoined by scripture and social law, then one's mind is cleansed of its dirt of past impure impression. Thereupon the mind becomes capable of reflecting uninterruptedly on the real nature of the soul and of realizing its total identity with the Supreme, by means of which alone one can regain the total freedom from the cycle of birth and death. Thus it came to be recognised: for its higher utility and spiritual purposefulness, it is only the philosophy of action that has to depend on the philosophy of renunciation.

This release of Vedānta from the clutches of *Karmakāṇḍa* marks the beginning of a new era in the history of Indian philosophy and education. It gave a good boost to Vedānta literature and its study. This started flourishing with an unprecedented speed and vigour. Not only that the recognition of performing the enjoined act like sacrifice only as a purifier of mind engaged in self-meditation opened the flood-gate. It released the rushing flood of Bhakti movement with variety of its literature; the temple-worship culture with its wonderful Āgama, Śilpa and ritual literature; the philosophy of *Upāsana* (religious meditation on personal god) with its vast but enigmatic Tantric literature; sects like the Śaiva, the Vaiṣṇava, the Śākta, etc.—all coming in and gathering momentum, all claiming that their literature is scripture, and all aiming at educating man to purify his mind, dirt, and all helping him in his task of unfettering himself from the cycle of birth and death and in regaining his original freedom-state.

The basic literary works of everyone of these systems and movement claimed, not unjustifiably, for themselves a status of being scriptures of the Vedic fold. For, they too, like the famous *Mahābhārata*, owed allegiance to the Veda and drew strength from the same source. They added enormously to that branch of literature which is conducive to the wisdom of culture (*jñāna, vidyā*). Till now this type of literature was monopoly of the higher stratum of society. But, there existed no theoretical barrier now to prevent the lower strata from studying and mastering any one of these new scriptures. Thus, the new era opened more vista to learning and made the base of education broader.

V

Let us now turn from the theoretical side to the practical side of education. At the outset, it is to be noted that the system of education during the period of our concern did not change much from what it was earlier. In ancient India, education was never a state subject. As Kautilya, the zealous advocate of the all-powerful monarchy lays down,¹⁰ the matter of educating, controlling and disciplining students was left to the authority of teachers.

The elementary education of the child usually commenced at the age of three. This commencement was marked by the ceremony of tonsure of the boy. The general practice was to teach him first the use and writing of alphabet (*lipi*) and simple arithmetic (*saṅkhyāna*).¹¹ Slowly he learnt subjects like story-telling, simple grammar, simple music and arts. He had also mental exercise in memorising stories, devotional hymns and prose passages from the well-known literary works, epics and Purāṇas and also fables of moral import and worldly wisdom. Side by side, he was also taught good manners, obedience to elders and also how to look after oneself as far as possible in one's daily routine and to do prayers daily. These things prepared the boy for his life of discipline in the *gurukula*, to which he would be sent in due course. We hear about the young children, intelligent enough to be taught even serious subjects like logic, economics and political science.¹² The Vedas and Vedāṅgas were not taught to the boys at this stage.

The primary education would be more or less common for the children of almost all communities. The mother's role as the first natural instructor and moulder of character of the child had been respectfully acknowledged.¹³ As and when the child grew and started learning more and more, the father was his second natural teacher in most cases. Even today, it is the parents who bear generally the first and entire responsibility to educate their children properly so that they will be good, disciplined citizens. Thus, when a child grew to boyhood and needed to be taught a higher special subject, in those days it was the society at large and the community in particular that decided what subject a student of a given community should study. Thus on the whole education was a subject of the community and society only.

Yet, the state had generally taken upon itself an overall responsibility to see that its citizens were on the whole educated and, as a result, behaved as well-disciplined citizens. Hence the Mauryan emperor Aśoka thought it necessary to issue edict after edict bearing his fervent and persuasive appeals and harangues to his subjects, with a view of educating them all to behave as disciplined citizens, respecting parents, elders and teachers, to live up to the values of life and of religion, and to cultivate tolerance between

communities. Kalidāsa describes the king Dilīpa as a father to his subjects, because, besides protecting and supporting them, he inculcated in them the spirit of discipline (*prājānām vinayādhānāt*) obviously by helping them in getting proper education. For, discipline is the product of proper education.¹⁴ This reflects the ideal set for the state during the Gupta age.

VI

The first stage of education, i.e., the primary and general study of the child came to an end when he grew up to be a boy of eight, eleven or twelve. Now, he was to enter the second stage, a crucial stage in his intellectual development. Here he was to learn serious subjects under stricter discipline. In the case of a boy belonging to the upper strata of the society, his entrance into this stage must be preceded by his *upanayana* or investiture ceremony, so that he would be eligible for taking up Vedic studies. The term *upanayana* actually signifies 'taking the boy to the (abode of) teacher'. However, in those cases where the father himself had the capacity to teach his son, he retained him to teach the subjects he had learnt and mastered. Such a father could boast himself as *mahāguru*, 'great teacher'.

However, if father was not alive, or the living father, for one reason or the other, was not able to teach his own son properly, the latter was sent to the abode of a teacher (*gurukula*, *ācāryakula*) who was a learned scholar, or master physician or artist or artisan, etc., of his community. This arrangement was particularly necessary wheresoever the subject, to be learnt by the pupil, demanded higher skill, greater attention, more experience, and better vision on the part of the teacher. In the teacher's abode the boy studied as devoted student. The terms *śiṣya*, *antevāsin*, *chātra*, *brahmacārin*¹⁵ and the like were in use to denote the pupil. Similarly the teacher was used to be referred to as *ācārya*, *upādhyāya*, *guru*¹⁶ and so on. These terms suggest what were expected of the students and teachers in those days (see notes).

It has been well recognised that education is a process that connects the master, who teaches and the student who learns. So, both the master and the student exerted and prayed for the total success of their joint venture, viz. education.¹⁷ Rather, education is a cart that moves on the two wheels, viz. the master and the pupil. So, for the proper running of the vehicle both these wheels are important and therefore are to be protected and maintained. In other words, the teacher should get some suitable remuneration or honorarium, so that he may maintain himself and his family with minimum comforts at least, and live peacefully so that he could devote his

time freely in teaching his subjects to his pupils. Likewise, the students also should be looked after properly. They must be provided at least with basic necessities of food, water, cloth and shelter during the years of their study. All these needed large amount of money and finance and also proper care. How to get them all? The ancients seem to have fully realised that education is a permanent subject of the nation and is the foundation of the nation's glorious culture. Hence, all schemes that were to be planned, and arrangements suggested, they all had to be practical, permanent, self-supporting, self-perpetuating, free from the interference of the state and the rulers and they must be as broad-based as possible. Above all, they ought to be *dhārmic* and righteous. Having all this in view, the ancients solved the problem in their own way. They managed to maintain the two wheels of the education-cart in two different but *dhārmic* ways, and helped the cart move on and on smoothly.

VII

A student, after his investiture, arrived at a Vedic *gurukula* seeking admission, and the teacher put questions to the entrant or his guardians who took him there, about the pedigree (*gotra*), about his branch of the Veda (*śākhā*) and of the school of ritual practices (*sūtra*), and about his father, grandfather and great-grandfather. By the answers of the entrant, the master would satisfy himself as to whether the entrant was twice-born and belonged to the family of faithful adherents of the Vedic principles. He then would admit the boy as an inmate of the *gurukula*. These questions were irrelevant in the context of the non-Vedic *gurukulas*.

In ancient India education was free. At the time of admission, there figured no question of tuition-fee or the teacher's fixed remunerations. To be a teacher, hired on a fixed salary (*bhṛtakādhyāpaka*) was viewed as a great sin. Those who taught sacred literature for the benefit of money and the like were denigrated as sellers of the Veda (*vedavikrayins*) condemned to hell.¹⁸ Even the masters of music and dance looked down their profession as a shameful trade on knowledge, if it were to earn their livelihood alone.¹⁹ But all this did not prevent a teacher from receiving gifts offered voluntarily by their rich pupils out of love and veneration. The sage Yājñavalkya accepted rich gifts offered by the king Janaka.²⁰ When Nāgasena was sent to a *gurukula* for Vedic study, his father gave rich gifts to the master.²¹ Droṇācārya is depicted to have received variety of gifts when he accepted the Pāṇḍava and Kaurava princes as his pupils.²²

However, on the completion of one's Vedic study, one is generally expected to offer to the teacher monetary gift (*dhanam āhṛtya*) if the latter so desired.²³ In such cases, the student, if poor, could approach the rich or the king of the land for money and offer the same to the teacher as *gurudakṣiṇā*.²⁴ These offers were made obviously with an idea that the master would, by the gifts offered, be able to maintain himself, his family and also his pupils and carry on his pious mission of propagating the Vedic knowledge and *Dharma*.

The age-old belief was that mastering the Vedas and teaching them to deserving students (*svādhyāyapracāre*) jointly constitute one very important part of penance (*tapah*) and no Vedic student should neglect the two²⁵ at any time. Therefore, when a *brahmacārī* approached the teacher for Vedic study, the latter felt happy that the former had come to help him in fulfilling that penance.²⁶ There was also a strong belief that the Vedic scholar who refused or failed to impart his Vedic knowledge to deserving and requesting students would be a sinner fit to be reborn as a mango tree.²⁷

Above all, by imparting Vedic knowledge to deserving disciples, the master helps them in their most pious and noble effort to gain spiritual knowledge, to realize the identity of the soul with the Supreme, i.e., regain his final emancipation. Therefore, teaching Veda is the highest and noblest form of gifts.²⁸ Therefore, a *Dhārmika* (the one who is devoted to the principles of *Dharma*) should be very glad to give this gift.

It deserves to be particularly noted that the age under our study witnessed the rise of a new powerful theory propagated vigorously by the *Prābhākaras*, the most vociferous of the *Dharma Mīmāṃsakas*. According to this theory, the Vedic learning (i.e. the tradition of it) depends on the authority of the scriptural injunction ordaining that 'one should teach Veda to a brahmin after (or if) the latter had undergone the investiture at the age of eight'.²⁹ This theory was built up against the Bhāṭṭa Mīmāṃsaka theory that the Vedic learning stands on the authority of the Vedic injunction that one should learn the Veda.³⁰ The former theory perhaps receives supports from the sages of the Upaniṣads, from Manu and from Kālidāsa.³¹ Besides, it seems logical also. For, the boys at the age of eight when they were expected to commence their Vedic study, would be quite oblivious of the very existence of the Vedic injunction, the Bhāṭṭa Mīmāṃsaka cites.

All this perhaps explains the rise of a class of highly qualified brahmin paṇḍits, not caring even for their basic necessities, went on teaching very difficult texts to their pupils and propagating knowledge and *Dharma*. The Chinese travellers Yuan Chwang and I-tsing were very much impressed by their scholarship, erudition, dedication and missionary spirit.³² These two

Chinese travellers also give details as to how the Buddhist Bhikṣu teachers followed the example of their brahmin counterparts and even excelled them in many aspects.³³ Thus it is only a deep devotion to *Dharma* on the part of both the orthodox and heterodox teachers that induced them to offer their service voluntarily for propagating education and *Dharma* without considering comforts and monetary gain. Indeed these selfless teachers had their forerunners in the earlier age too. For example, a brahmin by name Soma-yaśas of the first century AD, a master of the Kāṭhāsākhā and a native of the Sāketa country, i.e. Ayodhya region (U.P.) migrated all the way to northern Karnāṭaka, taught Veda, propagated Vedic *pravṛttidharma* by performing as many as eighty Vedic sacrifices, made friends with local population and passed away there in AD 105. Out of love and regard his friends erected a stone pillar in his memory.³⁴

The great Buddhist *ācāryas* like Dignāga, Dharmapāla, Dharmakīrti, Śāṅkarasvāmin etc., originally of the Kāñcī region in the far south and also other teachers from the far West and Central India went to Nālandā in the far north simply with a view to serving the cause of the *Dharma* and to help people at large in their quest for enlightenment. Śrī Śāṅkara, a brahmin boy of Kerala, travelled as far north as the banks of the Narmadā in Madhya Pradesh to become a monk, and went still farther to Vārāṇasī and Badrināth to produce his monumental treatises. He is also said to have travelled, in those days, on foot, propagating the Vedic *nivṛttidharma* and the message of enlightenment in every corner of the Indian subcontinent. Examples can be easily added.

Thus the problem of the teacher's remuneration and maintenance was solved to a great extent by an appeal to the *Dharma* eternal. Of course, the problem itself did not arise in the case of those teachers who were themselves rich enough to maintain not only themselves and their families, but also number of students to whom they taught the Vedas, Vedāṅgas, philosophy, etc. Besides, the rulers of different regions of ancient India helped in their own way in solving this problem. To this part of our study, we shall turn next.

VIII

We saw already that the kings of different states in ancient India and their subordinates were interested in making their subjects educated and disciplined. Having this object in view, they issued charters founding *brahmapurīs* and *agrahāras*, i.e., settlements of brahmins, who had mastered the Vedas,

Vedāṅgas, etc. The rulers also issued charters making rent-free and tax-free land grants or instituting rich endowments in favour of individual Vedic scholars. The aim of these donors in issuing the charters is said to acquire *Dharma*, *Punya* (merit) for themselves and for their parents etc., and to gain fame. These grants should indeed generate *Dharma* because they would go a long way in relieving the donees of their big problem of maintaining themselves and their families and enable them to devote all their time in teaching and in propagating the Vedic knowledge and *Dharma* for the welfare of the entire world.

Further, as we saw above, the *brahmadāna*, i.e. teaching and imparting Vedic knowledge is the highest and most meritorious of all the gifts known.³⁵ For, it opens the recipient's inner eyes and helps him in regaining emancipation. But *Dharma* itself prevents the kings from teaching the Veda, the *Karmakāṇḍa* directly to any one. Hence, they made the above gifts and by that means and through the donees they were able to make the said *brahmadāna*. With the same end in view, the kings and others of different regions of India also founded educational institutions, with ample resources. These were variously known as *cāturvaidyāśālā*, *pāṭhaśālā*, *śālā*, *ghaṭikā*, *maṭha*, etc. In these institutions there were on their staff scholars who were well versed in the Vedas, in their accessories, and in different systems of philosophy. These teachers would impart Vedic and philosophical knowledge to a large number of deserving students at various levels. Such institutions were found almost in all parts of India in ancient times.

Furthermore, the rulers of ancient India did not stop with founding the Vedic study centres and patronising them alone. They also gladly established Buddhist *viḥāras*, monasteries and provided them with enough and more finance for propagating Buddha Dharma. Kumāra Gupta I Mahendrāditya (AD 415–55) of the Imperial Gupta dynasty, who was a devout Vaiṣṇava (*paramabhāgavata*) and who performed the great Vedic Aśvamedha sacrifice, founded the famous Buddhist Mahāyāna University (*mahāvihāra*) at Nālandā (about 80 km from Gayā) in Magadha and generously gave gifts for its maintenance. Here in this Mahāvihāra there were on its staff, many great Paṇḍita-monks who taught a large number of students various subjects—Buddhist and non-Buddhist, Vedic and secular subjects. Kumāragupta's successors continued to patronise this Mahāvihāra. The Paramamāheśvara Harṣavardhana contributed enormously for its development. The Chinese pilgrims Yuan Chwang and I-tsing had been inmates of this University. From their accounts we get valuable informations about the organisation, syllabus, etc., of this Mahāvihāra. Besides these travellers, many more Buddhist pilgrims from China, Korea, Tibet, Tokhra came all

the way to the Nālandā university for higher studies and for procuring rare manuscripts. After Harṣavardhana, the Buddhist rulers of the Pāla dynasty of Bengal and Bihar patronised it. The university continued to flourish till the twelfth century when it was, along with its huge valuable library, was unfortunately destroyed by the Muslim invaders under Iltutmish (AD 1211–36).

The first Pāla ruler Gopāla I (c. 765) was Buddhist. He founded a university at Odantapuri (near Nālandā). His son and successor Dharmapāla founded a monastic college at Vikramaśīla on the southern banks of the Gaṅgā (exact location is doubtful). It was an ably administered monastery devoted to propagate Buddha dharma for about four hundred years till it was destroyed by the Mohammadans under Bakhtyar Khilji in AD 1203.

The rulers of the Maitraka dynasty founded a Hinayāna Buddhist Mahāvidyālaya in Valabhī (modern Wala or Vāla) in the eastern Saurashtra or Kathiawad Peninsula in the fifth century. It was also ably propagating Buddha Dharma for a considerable period. The Chinese pilgrims Yuan Chwang and I-tsing visited it and stayed here for some time for pursuing their studies. The *Kathāsaritsāgara* tells us that a Brahmin of the Gangetic plain sent his son to this Mahāvidyālaya in preference to the nearby education centres in Vārāṇasī and Nālandā. Maybe the Valabhī University offered some good and even better course also in the non-Buddhist subjects of the orthodox Vedic schools.³⁶

The Maitrakas also encouraged Jaina studies. Hence the great Jain Council of AD 454 was held in the very Maitraka Capital Valabhī itself and the Jain canon of the Śvetāmbaras was committed to writing and many copies of it produced and distributed.³⁷

The early rulers of the Śālaṅkāyana dynasty (fourth-fifth century AD) of Andhra Pradesh claimed to have acquired great merit by building Śiva and Viṣṇu temples etc. and also by establishing in their kingdom *cāturvaidyaśālās* where the four Vedas and their *aṅgas* were taught.³⁸

The most orthodox Vedists of the Viṣṇukunḍi royal family (fifth-sixth centuries) of Andhra Pradesh and their feudatories established on the banks of the Kṛṣṇā and Godāvarī, colleges (*ghaṭikās*—see below) for Vedic and philosophical studies—including *ghaṭikās* for *Atharvaveda* and also side by side built Mahāvihāras for Buddhist monastic education and gave liberal grants to both. One such monastery was dedicated to the community of the Buddhist monks from Ceylone (*Tāmrāparṇīya*). The *Atharvan* recitation in the *ghaṭikās* on the banks of the Godāvarī seems to have continued for many centuries and this has been referred to as an authority by the Advaita writer Amalānanda of the thirteenth century.³⁹

The Pallavas of Kāñcī were staunch Śaivites at heart. An early member of the dynasty founded a *ghaṭikā* for the Vedic and Śāstric studies and also a monastery for Buddhist-studies. This *ghaṭikā* was so famous and so well organised that it attracted students from far and near for higher studies. The highly learned staff members of the *ghaṭikā* along with the members of the royal house had played a crucial role in averting a great crisis of anarchy in the Pallava empire by successfully crowning Nandivarman II in AD 730, on the Pallava throne when Paramēśvaravarman II died leaving behind no issue to succeed to power. All this vouch for the high esteem in which the scholars of the *ghaṭikā* were held by the public, by the members of the royal house and by the king's officials. The Chinese pilgrim too testifies that the people of Kāñcī had much esteem for high learning of scholars. Yuwan Chwang who visited Kāñcī in AD 640 speaks of the existence of about hundred active monasteries in the city in which more than 10,000 monks were devoting their time in Buddhist studies and practices. The pilgrim says that near the southern boundary of the capital a large monastery served as a rendezvous for the eminent men of the country. Maybe this was the *Rājavihāra*, i.e. the monastery maintained by the king, referred to by Mahendravarman I Pallava in his farce *Mattavilāsaprahasana*. And perhaps this was the important monastery to which the Tamil classic *Maṇimekhalai* contains some valuable reference. It is also said that a part of Kāñcī with a group of Buddhist monasteries bore the name *Buddhakāñcī*.⁴⁰

As Yuan Chwang testifies that the Digambara form of Jainism also continued to be popular in Kāñcī even though Mahendravarman I, according to some, changed his religion from Jainism to Śaivism. And even today we find in the outskirts of the city a settlement called Jinakāñcī with Jain temples. Further, during this age, the Western Gaṅgas of Talakāḍu, Cālukyas of Bādāmī, the Rāṣṭrakūṭas of Mālkeḍ, who all belonged to the orthodox religion, tolerated and even favoured and encouraged Jainism and Buddhism and also their literature and education.

Thus, out of their high regard for *dharma*, the kings of the age came forward to solve the problem of education, viz., the big problem of finance in maintaining, with no interference of the power of the state, the teachers and students, the two limbs of education in general. While concluding this section, it deserves to be noted that starting from the Imperial Guptas, almost all the kings of our period were faithful adherents to the one or the other sect of the Vedic orthodox religion. Yet, with a remarkable sense of toleration they encouraged and patronized the propagation and education of heterodox religions and the growth of their literature and education. Indeed, knowingly or unknowingly, they all were faithfully following the unique advice

of the Maurya emperor Aśoka: '... Deprecation (of other sects) should be on specific reason only, because the sects of other people deserves reverence for the one reason or another. By acting thus, a man exalts his own sect, and at the same time does service to the sects of other people ...'.⁴¹ That is why almost all the kings of our period were like Aśoka again, revering all religions and their denominations with various kinds of honour.⁴² This was the happy trend set by the intelligent people of the age at large who had a good training and proper education to achieve this ideal of the wisdom of culture of Bhārat. This trend is reflected in the observation of a philosopher of the age: a religion or philosophy wedded to the supreme truth alone has no quarrels with different sects even when the latter, adhering to non-essentials and hence to untruth, quarrel among themselves in establishing their own respective views.⁴³

IX

Earlier we referred to the problem of maintaining students during the period of their study in the *gurukula* in ancient times. Now let us try to understand how this problem too was narrowed down and solved.

Where sons learnt subjects from their respective fathers, staying in their own houses, the problem of their maintenance did not matter much. Again, even in those cases where the boys had to go to a far off place and learn from some other master-artisans the professional subjects like carpentry, blacksmithy, pottery, weaving, building construction and so on, there too the problem was not great. For, these students could themselves earn their food and clothes even while learning their respective subjects. The master-craftsmen also could enhance their own professional income by getting assistance from their pupils and trainees in their professions. The multi-dimensional building activities of the state, the king, the rich and the ordinary individuals of society were in constant need of craftsmen, artisans, architects, etc. The archaeological monuments of the age, even in their present dilapidated condition, indicate the great magnitude of the building activities of the age.

The same must have been the case also with the students and masters in the field of arts, music, dance, medicine and so on. The dramas, romances and other literature of the age speak volumes on the favour and encouragement accorded to different artists, musicians, dancers, dramatists, etc. by the princes, the princesses and the opulent sections in the society. In fact, the *Nārada-smṛiti* of the period clearly lays down the law that the master-artist, musician, physician, etc., should, with parental affection and care, teach

their subjects to their students and provide them food, cloth and shelter in their own houses; that the students should live in the house of the masters and not anywhere else; and that whatever the students earn by their skill and labour should belong to their masters only.⁴⁴

During the period, the kings were in the habit of giving lands, made tax-free, to their military officers, who in return used to supply trained warriors to the royal army. Besides, the feudatories also were expected to keep contingents of able soldiers, ever ready to help their respective overlords in wars. Further, the military trainees (*cāṭa-bhaṭa* or *chātra-bhaṭa*) often used to enter some prosperous village and forcibly appropriate the agricultural products for themselves. When questioned, they would produce some false order of their chief. Hence the kings had to take enough care, so that the *cāṭa-bhaṭas* might not bully the villages granted as *brahmaṇḍas* for encouraging the Vedic learning. Thus the education of the science of warfare, the maintenance of the military trainees, and running the army staff-college had never been a great problem, because the states had to take all the responsibility in the matter.

The problem could, therefore, arise only in those branches of education where in the normal course the students were not themselves likely to earn their food and cloth while learning their subjects and where by teaching lessons to the students the teachers too could not add anything to their monetary income directly. To this category belonged the students and teachers of the subjects, like the Vedas, Vedāṅgas, religion, philosophy, etc., i.e., the lessons on the soul, its transmigration, the *Dharma*, the God, the heaven, the Supreme and the mutual connection of these and allied subjects. We already saw that these subjects fall within the realm of the wisdom of culture. The other set of subjects mentioned earlier, the maintenance of students and teachers of which was not a big problem, belong to the province of the wisdom of civilization (see above).

It has been pointed out that the wisdom of culture and the subjects conducive to this wisdom help man to break off his internal fetters, to know his own soul and the God and to go to the heaven, to realize the identity of the soul with the Supreme and to attain total liberation. Hence these came to be regarded by the ancient thinkers as more valuable (*Parā Vidyā*) than wisdom of civilization and the group of subjects pertaining to this wisdom of civilization (*Aparā Vidyā*) that is concerned with man's liberation only in his bodily level. Therefore, all the people great and small, rich and poor, learned and mediocre, all deemed it a great *Dharma* to do everything possible to preserve the Veda, Vedānta and other allied subjects so that they can be transmitted in their pristine purity to the posterity. Hence, just as

to teach the Veda etc., with a little or no remuneration, was deemed as a great *Dharma* by the teaching community; and just as to help, in one way or another, the propagation of this education was considered as *Dharma* by the community of the rulers and their subordinates; so also to learn the Veda, Vedānta etc., was valued as *Dharma* sublime by the student community, even though they were aware that for this learning purpose they had to change over from their present life of comforts to that of strict austerity and severe discipline. Above all, their pious parents too thought it an essential *Dharma* to allow their beloved sons to live such an austere life of a *brahmacārin* in the *gurukula*.

Indeed as we saw above there were educational institutions established and maintained by rich gifts by the kings; and the teachers themselves were maintaining their students. But they must have been too small in number to meet the ever growing great demand. So in the majority of the *gurukulas*, the pupils—whether they were born-rich or born-poor—had to live only on that cooked food which they got for themselves by begging house to house in the nearby villages and towns.

This act of maintaining oneself for studying scriptures is known as *bhikṣācaraṇa*. It is said that though born-rich, Śaṅkarācārya maintained himself by *bhikṣācaraṇa*. Alberuni (eleventh century) had observed the Vedic students going around the township begging food.⁴⁵ During the thirties of the twentieth century too, when the present writer was a student inmate in the Vedapāṭhaśālā, some of his classmates still preferred to have *bhikṣācaraṇa*, instead of eating the free food given in the Pāṭhaśālā. The idea was that former was the most pious form available for *brahmacārin* for maintaining himself.⁴⁶

This practice of *bhikṣācaraṇa* made the maintenance of the Vedic students a collective responsibility of the society: every house, every family deemed it an honour and pious duty, a *Dharma*, to contribute daily, with faith and devotion, its mite, at least a few morsels of cooked food to a scholar, devoted to the Vedic, scriptural and philosophical learning. Thanks to this arrangement, the pupils of the *gurukulas* felt always indebted to the society. Hence when they grew adults, wherever they would be and whatsoever might be their status, they would be ever ready to serve, with a deep sense of gratitude the same society which supported them in their students days. Moreover, to get regular *bhikṣā* from the members of the society, the students had to naturally prove themselves well-behaved highly disciplined students.

Besides, in the *gurukula*, the pupils commenced their study with learning that particular branch or *śākhā* of the Veda, which they inherited from their father and forefathers (*svādhyāya*). The opportunity to learn other

subjects depended totally on individual pupil's intelligence, industry, discipline, continued readiness to serve the teacher ungrudgingly (*suśrūṣā*) and intense desire to learn a particular subject (*jijñāsā*). Thus the system of ancient Indian education eliminated the cases of student indiscipline, a comparatively modern ugly phenomenon, and it made, to a great extent, every pupil a true disciple, i.e. a student with discipline.

X

Education, thus freed ably from the basic problem of maintaining the teacher and the taught, could flourish on its own accord, with no major hindrance, in various branches under the able guidance of the dynamic teachers of ancient India. All the great authors of the age were products of this *gurukula* system of education. Bāṇa Bhaṭṭa refers to his own unexpected return (*samāvṛtta*) from *gurukula*, due to the sudden demise of his father and also to his subsequent studies in various brilliant *gurukulas*, that were imparting knowledge of spotless sciences.⁴⁷ In the *Daśakumāracarita*, Ācārya Daṇḍin narrates how the young hero Rājavāhana and his nine comrades in arms had their education in the hermitage of the sage Vāmadeva and learnt many subjects from master-tutors and attained proficiency in all scripts and languages, the Vedas with their auxiliaries, poetry, drama, arts, fables, epics, romances, the Purāṇas, Dharmaśāstra, grammar, astrology, astronomy, logic, Mīmāṃsā, the Kautilya and Kāmandaka schools of political science, music, dance, poetics, military science, use of all the variety of weapons, etc., and also the art of thieving, gambling, fraud, etc.⁴⁸ In his *Kādambarī*, Bāṇa again describes, in his usual graphic manner, how the hero Candrāpīḍa got his education in a specially created abode and mastered under able teachers almost all branches of learning within a period of ten years.⁴⁹ The subjects that are listed by Bāṇa in this context is more or less identical with the those given by Daṇḍin.

The ideal condition of the *gurukula* of the age one can find in Bāṇa's inimitable description of the educational and intellectual activities of the sylvan Āśrama headed by the Buddhist monk Divākaramitra in the Vindhya forest. The monk had been earlier a great brahmin scholar. In his Āśrama Harṣa saw representatives of numerous sects, philosophical schools absorbed in their intellectual and spiritual pursuits, all living in perfect harmony. There were: Buddhists of various schools, devotees who were dead to all worldly passions, Jains in white robes, brahmin mendicants also in white robes, followers of Śrī Kṛṣṇa sect, brahmin Brahmacārins, ascetics who had pulled out all their hair, Sāṅkhyas, Vaiśeṣikas, adherents to the

Upaniṣadic doctrines, those holding God only as the efficient cause of the universe, Dharmaśāstrins, Paurāṇikas, Yājñikas, grammarians, Pāñcarātrikas, etc., all diligently following their own tenets, intelligently pondering, teaching their respective subjects, raising doubts and resolving them, urging objections and answering them, giving etymologies, disputing, studying, explaining and so on—and all gathered as Divākaramitra's students.⁵⁰

Maybe Bāṇa and Daṇḍin paint their pictures more thickly than the reality demanded. Yet, it is certain that fixing this ideal in their minds, the ancient Indian thinkers and teachers ran the *gurukulas* of the individual masters, and administered the *Cāturvaidyaśālās*, *ghaṭikās*, etc., founded and aided by the rulers. Bhavabhūti (AD 700–750) reflects the status of his contemporary *gurukulas* when he describes the system of multidimensional education system followed in the Āśrama of Vālmiki on the banks of the Gaṅgā. He also gives us to understand that the students who could not stand the discipline and high standard of the course here, had to migrate to the *gurukulāśrama* of Agastya in the Daṇḍaka forest.⁵¹ Contemporary epigraphs tell us that students like Mayūraśarman (c. AD 400), after studying the Vedic lore in some education centre in his home country Vanavāsa, moved for further studies to the university-like *ghaṭikā* of Kāñcī.⁵² We already saw that non-Buddhist subjects like the Veda had been included in the curricula of the Nālandā Mahāyāna University. For details regarding many more faces of the practical side of the ancient Indian education system, the readers' attention is drawn to the two books of Prof. A.S. Altekar and Prof. R.K. Mookerji (referred to at the outset) and to the two long papers of the present writer appeared recently elsewhere.⁵³

Before we conclude this section, it is good to see a little about the examination system adopted in ancient times to test the proficiency of the scholars in the field of the Veda and of the subjects of their specializations. Different symbols denoting portions of the Vedas were written on bits of palm-leaves or some such things (*lekhyas*). They were put into a *ghaṭikā*, a small pot. Thus the pot was a sort of question bank. Similar pots were prepared for other subjects also. When the candidates appeared for examinations in the Vedas or other subjects, the respective *ghaṭikās* or pots were brought before them, the *lekhyas* were taken out of them by lot and questions were asked accordingly. The degree of proficiency of a scholar in a given field of learning depended on the number of questions he answered correctly. Now it is obvious that just as the time unit called *ghaṭikā* derived its name from the vessel *ghaṭikā*, by means of which it was measured,⁵⁴ so also *ghaṭikā* as an educational institution derived its name from the vessel *ghaṭikā* by means of which the institution conducted its examinations.

We hear about *ghaṇṭikopādhyāya* 'a teacher of the school (called) *ghaṇṭikā*', in the *Mahābhāṣya* and other works of North India. We know *ghaṇṭikā* is also a name of a vessel. Maybe, there the examinations were conducted using a *ghaṇṭikā* instead of *ghaṭikā*. Till recent times *śalākāparīkṣā*; (i.e., mode of examining students from that page whichever is opened by a *śalākā* (a thin pin) inserted into the book of palm leaves) was in practice. It is likely that the educational institutions such as *cāturvaidyāśālā*, *maṭha*, etc., adopted one of these or similar other lot system for examining the candidates. Indeed this way of examination is fool-proof. It plugged all the holes of the leakage of question papers—an unpleasant phenomenon recurring again and again in our modern system of examination. It should be noted that using a tray for the pot, a similar system of examination is said to have been in vogue in some of the universities in the former USSR.

The poet and poetician Rājaśekhara, in his well-known *Kāvya-mīmāṃsā*, tells us that in many great cities there were centres (*sabhās*) of examining the proficiency and depth of scholarship of Paṇḍitas and poets.⁵⁵ There existed *Brahmasabhās* 'Assembly Halls of the Learned' in the capital cities like Ujjayinī, Pāṭalīputra, etc. They were founded by great kings like Vāsudeva (the last great Kuṣāṇa king of the second century AD), Sātavāhana (Śātakarṇi I of the first century BC), Vikramāditya (Chandragupta II Vikramāditya of the fourth century AD). Great poets and eminent scholars and teachers are said to have proved their proficiency in their respective fields, presumably by winning scholastic debates with the master scholars of those societies. It is also stated that these *sabhās* honoured the successful scholars by crowning them with tiara (*paṭṭabandha*) and by taking them in a grand procession on a car known as 'a car of knowledge' (*Brahma ratha* or *yāna*). Rājaśekhara's list of poets and scholars who won the above honour includes the great poets like Kālidāsa, Bhartṛmeṇṭha, Āryaśūra, Bhāravi, Haricandra, Candragupta, etc., and the great teachers, like Varṣa, Upavarṣa, Pāṇini, Piṅgala, Vyāḍi, Vararuci, Patañjali, etc.⁵⁶

EPILOGUE

In this manner during that age education reigned supreme as the only means to gain the wisdom of civilization and the wisdom of culture and to regain freedom. However, by the end of our period the outlook of the thinkers and educationists of India seem to have been suffering a setback on three accounts.

- (1) Vātsyāyana, the author of the *Nyāyabhāṣya* (c. AD 350) bracketed the sages (*ṛṣis*), the gentlemen of Bhārat (*āryas*) and foreigners

(*mlecchas*) together as reliable persons (*āpta*) whose words could enjoy the status of the verbal authority (*śabdapramāṇa*).⁵⁷ So also the great Indian astronomer Varāhamihira (c. AD 500), in his *Brhatsaṃhitā* declared in unequivocal terms: the Greeks (*Yavanāḥ*) were foreigners (*mlecchas*). But they too were great masters in the science of astronomy (*idaṃ śāstram*). Hence they too were worshipped like the sages (*rṣivat te'pi pūjyante*).⁵⁸ But by AD 1000 this open-mindedness and receptivity of the Indian mind gave way to close-mindedness and abhorrence to foreign ideas. Hence Alberuni, in his *Kitab-ul-Hind* (AD 1030), testified that the Indian scholars had developed a supreme contempt for the scholarship of foreigners, born of their consciousness that they were the most learned people in the world.⁵⁹

- (2) It is well known that during that age there had been often exodus of brahmins from the Vedic schools to the Buddhistic studies (Bauddhāgama). Udayanācārya (AD 950–1000), the last greatest logician of the age thought it fit to explain this unfavourable trend as: the capacity of the brahmins in understanding the scriptures waned rapidly due to their decaying spiritual strength, faith, and self-control. For such weak people it is hard to follow the Vedic path, because it demands care, attention, clarity of vision, great effort, an attitude of non-attachment and the like on the part of the seeker. On the other hand, to take up the study and the path of the Buddhism, with its allurements of easily available food and cloth, appealed to the lazy, worldly, illogical and unqualified people.⁶⁰
- (3) We saw above: the community of the brahmin teachers viewed it as its *Dharma* and penance to teach the Vedas to deserving students freely and hence abhorred teaching for fixed salary; the student community too took as its *Dharma* to learn Vedas as obedient disciples and live on food got through begging. But, with the rise of the state-aided *Cāturvaidyaśālās* and the *ghaṭikās*, etc., both these communities allowed this great ideal of *Dharma* to slacken slowly. Hence the founders of the Vedic *pāṭhaśālās*, *maṭhas*, etc. in the subsequent age, i.e., in the eleventh century itself, thought it essential to provide for the teachers fixed daily or monthly salaries and for the students' regular daily food.⁶¹

NOTES AND REFERENCES

1. Cf. the dictum: *svabhāvo duratikramah*.
2. Let us here ignore their mutual differences in defining and explaining what they mean by *correct knowledge* and by *freedom*.
3. Cf. *Uddhared ātmanā ātmānam* of the *Bhagavadgītā*, 6.5.
4. Cf. *Mokṣe dhīrjñānam anyatra vijñānam śilpaśāstrayoh* of the Sanskrit lexicon: *Amrakośa* of the Gupta age.
5. Cf. *Brahmajijñāsā kartavyā*, etc., of the *Br.Sū. Bhāṣya* of Śrī Śaṅkara (1.1.1).
6. See the *Mahābhārata*, 18.5.49–50.
7. K.A.N. Sastri, *A History of South India* (IV edn, rpt., 1988), p. 367.
8. See the *Pūrva Mimāṃsāsūtras*, 1.1.2 ff., 1.2.1 ff, and the commentaries thereon.
9. See the *Kenopaniṣad*, 1.1.5; Śrī Śaṅkara's *Br.Sū. Bhāṣya*, 1.1.4; 2.1.21, etc.
10. *Kauṭīliya Arthaśāstra*, 1.5.6.
11. *Ibid.*, 1.5.7, *Raghuvamśa*, 3.29.
12. *Uttararāmacarita*, Act 2; *Mādhaviya Śaṅkaravijaya*, canto 3.
13. Śrī Śaṅkara, *Bṛhadāraṇyakabhāṣya*, 4.1.2.
14. Cf. the famous saying, *Vidyā dadāti vinayam* etc.
15. These four terms respectively signify 'he who is commanded'; 'the taught'; 'he who stays by the side of teacher'; 'he who maintains the secrecy of the teacher's drawbacks'; 'a celibate' (or 'a devout student of the Veda').
16. These three words signify respectively 'he who is capable of making students cultivate good behaviour'; 'he from whom pupils learn'; and 'he who puts an end to ignorance of the pupil'.
17. See Śrī Śaṅkara and his commentators under *Taittirīya Upaniṣad*, 1.1.1; 1.3.3; 2.1.1.
18. *Anuśāsanaparvan*, 24.70.
19. *Mālavikāgnimitra*, Act 2.
20. *Bṛhadāraṇyaka Upaniṣad*, 3.1.4; 4.1.1; 4.4.1.
21. *Miṇḍapāṇha* (SBE), I, p. 17.
22. *Mahābhārata*, *Ādiparvan*, ch. 122.
23. *Taittirīya Upaniṣad*, 1.11.1.
24. See for example Raghu-Kautsa episode in the *Raghuvamśa* (canto 5); the Uttanka episode in the *Mahābhārata*, *Ādiparvan*, ch. 3.
25. *Taittirīya Upaniṣad*, 1.9.1; 1.11.1.
26. Cf. *sa ācāryaṃ tapasā pīpartī* of the *Atharvaveda*, 11.5.1.
27. See the Smṛti passages quoted in the *Smṛtikaustubha*, p. 174.
28. Cf. *Sarveṣāṃ eva dānānāṃ brahmadānaṃ viśiṣyate*, in *Manusmṛti*, 4.233. Here *brahma* denotes Veda. See *Epigraphia Indica*, vol. 42, p. 82.
29. I.e., *aṣṭame varṣe brāhmaṇaṃ upanayīta, tam adhyāpayīta*.
30. I.e., *svādhyāyōdhyetavyaḥ*.
31. See *Chāndogyaupaniṣad*, 6.1.1; *Manusmṛti*, 2.140; *Raghuvamśa*, 1.25.
32. Beal, S., *Life of Hiuen Tsang*, by the Shaman Hwui-li (London, 1911), pp. 76, 136, 154, 160; Takakusu J.A., *A Record of Buddhist Religion as Practised in India and the Malay Archipelago*, by I-tsing, Oxford, 1896, p. 185.
33. For details see *Hist. and Culture of the Indian People*, vol. III; *The Classical Age*, ed. R.C. Majumdar, etc. (BVB, II impression, 1962), pp. 608 ff; A.S. Attekar, *Education in Ancient India* (1934), p. 260 ff.

34. *Epigraphia Indica*, vol. XXXIX, pp. 183 ff; *The Adyar Library Bulletin*, 1994 (vol. 58), pp. 100–1.
35. See notes 26–8 above.
36. For more details about these three monasteries, see Altekar, op. cit., pp. 260–79.
37. R. Sathianathier, *A Political and Cultural History of India*, vol. I: *Ancient India* (Madras, 1952), p. 229.
38. *Epigraphia Indica*, vol. XLII, p. 75 ff.
39. For details see S. Sankaranarayanan: (1) *The Viṣṇu-kuṇḍis and Their Times* (Delhi, 1977), pp. 37 ff, 90 ff, 142 ff.
40. See R. Sathianathier, op. cit., 317; S. Sankaranarayanan: (2) *Śrī Śaṅkara—His Life, Philosophy and Relevance to Man in Modern Times* (Madras, 1995), pp. 292–3.
41. The Twelfth Rock Edict of Aśoka.
42. The Sixth Pillar Edict of Aśoka.
43. Cf. *Gauḍapāḍakārikā*, 3.17.
44. The *Nārada-smṛti*, ed. R.W. Lariviere (Philadelphia, 1989), 5.16–18.
45. Sachau, *Alberuni's India* (London, 1888), vol. II, p. 131.
46. See for example, *Manu.*, 2.188.
47. *The Harṣacarita*, ed. P.V. Kane (ch. I), pp. 18–19.
48. *Daśakumāracarita* (NSP, 1913), pp. 22–3.
49. *Kādambarī* (NSP, 1948), pp. 168–9.
50. *The Harṣacarita*, op. cit. (ch. VIII), p. 73.
51. See the *Uttarāmacarita*, Act II.
52. See *Adyar Library Bulletin*, 1994 (vol. 58), pp. 101–2.
53. See 'Sanskrit Education in Ancient Tamil Country (An Epigraphical Survey)': *The Adyar Library Bulletin*, 1993 (vol. 57), pp. 7–33; 'Sanskrit Education in Ancient Karnataka', *ibid.*, 1994 (vol. 58), pp. 100–24.
54. See the *Sūryasiddhānta* (Calcutta, 1925), 13.23 and the commentary thereunder.
55. Even now there are such *sabhās* in Vijayawāḍa, Rājamunḍri, Hyderabad, in Andhra Pradesh and in Kāñchī in Tamilnadu.
56. See *Kāvyamīmāṃsā* of Rājaśekhara (GOS, no. 1, 3rd edn, 1934), pp. 54–5.
57. *Nyāyabhāṣya*, 1.1.7.
58. *Bṛahatsaṃhitā*, 2.14.
59. R. Sathianathier, op. cit., p. 344.
60. *Nyāyakusumāñjali* (Kasi Skt. series, no. 30, 1957), Book II, pp. 300–3.
61. See note 53 above.

A Perspective of Indian Science of Tenth-Eighteenth Centuries

A. RAHMAN

INTRODUCTION

Science has dual aspects. First, it is concerned with the method of acquiring knowledge, its systematization, interpretation and drawing conclusions from it to widen human horizons, to understand environment and use it to shape their future. Second, the use of the knowledge to shape social and cultural life and its becoming a part of the political process.

To understand the historical development of science one has to understand both, the evolution of the methodology of science as well as the political role it plays in society. In contemporary society one has to include the economic role as well.

To understand the political role one has to carefully study the language in which science is communicated; what it communicates and what it withholds, as well as to whom it is communicated and from whom it is withheld. One has also to study the base and spread of science in society in a particular culture in a defined period of history, the area it covers and the areas it is not able to cover or leaves out. The latter may either be due to inadequacy of methods or means available or due to social and political reasons it is found advisable not to tread the thorny path.

A critical study of the history of science against the backdrop of its social and cultural context would reveal a constant effort to control science, to meet the purposes and goals of the State. This is done both by containing the spread of science as well as imposing on it the myths and dogmas. Every

religious group maintains that everything worth knowing is available in the sacred text, and all one has to do is to unfold the meaning of what is given in the text and interpret it properly. Further, it is even suggested that if there is any contradiction between scientific knowledge and the sacred text, efforts should be made to modify scientific knowledge in conformity with what is given in the sacred text. New ideas as they were generated in different societies came up against the dead weight of tradition and very often scientists, espousing the cause of new ideas and promoting new knowledge were prosecuted and some even had to pay dearly with their lives.

Looking at the knowledge base of the society, it does appear as a part of the policy to limit it to the ruling elite, while for the mass, myths were promoted. In this process priestly class, and where priestly class did not exist, theologians or politicians were utilised by the State. This was so in ancient Egypt, Greece, India, Islamic world, and in Europe. We find this in evidence once again in contemporary society.

Isocrates, explaining the purpose of an Egyptian religious priest says:

The pious practices which he introduced were many and various; for he established by law that they should reverence and honour animals which are despised among us, not because he was under any misapprehension as to power of these creatures, but for two other reasons. The first was that he thought it proper to accustom the mob to obey any commands that were given to them by their supervisors; the second, that he wished to test by their attention to these public observances, the sentiments his subjects might entertain on matters which were difficult to observe. For he thought that men who despised these little observances might very well also feel contempt for more important things, whereas he could rely on those who displayed their piety to be equally law abiding in every other particular.¹

In Greece, Critias, a relative of Plato, gives us his ideas about the political origin of religion thus:

when the law hindered indeed wrongful works done by open violence, but men continued to do them by stealth, some shrewd and wise thoughted men found an object of awe for mortals, that these might be some object of dread to the wicked even if they do or say or think anything in secret. Whence he brought in the divinity . . . telling them that there is Deity . . . vigorous with imperishable life, hearing and seeing with the mind, with sense thought attending to these things, and clothed with a divine nature, who will hear all that is said among mortals and will have power to see all that is done.²

Aristotle has similar views when he says:

myths that have been introduced to persuade the multitude and on account of their in regard of social custom and public good.³

Throughout the history, when scientific knowledge created a new awareness of environment and opened up a possibility of enlightenment of people as a whole, efforts were made to contain knowledge in order to promote myths for popular consumption. With the advent of industrial society one notices a series of political myths as well as the exploitation of religion for political purpose.

In the study of History of science both the dimensions, as stated earlier viz., method of science, as well as the social role of science in society and the period concerned, are required to be investigated. Since in each period of the development of science in society, one may notice counter knowledge, i.e. that which negates the main conclusions of science.

It may be worthwhile to briefly elaborate the method of science to indicate the nature of conflict. It comprises observation and experimentation to collect the basic data. The data thus gathered is then analysed and systematised to draw preliminary conclusions, and correlated with the framework of existing theories or otherwise to develop alternative picture, after its validation by available procedure. The second dimension covers the manner of doing science, including the use of instruments, the teams which operate etc. The third dimension covers the context of science, which is validated and systematised knowledge, its social and cultural implications, political linkage and philosophical meanings and the interpretations given to various dimensions. Finally, is the language in which science is written and communicated amongst the scientific community and the people.

These steps and dimensions of science are often subject to critical comments and doubts by those who think there are alternate ways of acquiring knowledge or that the scientific method leaves out many dimensions of knowledge, or that its contents are narrow and comprise only those areas of knowledge which can be covered by its methods or the instruments used. Reality is large and many dimensional and the scientific methods and means of gaining knowledge can be compared to a fishing net, the size of the hole in the net restricts the size of the catch and, however, small the mesh is, something would always escape the net. Very often, intuitive knowledge, poetic and artistic perceptions and sensibilities are stated, to point out the limitations of scientific approach and limitation of knowledge. In addition, the mystic experience is also cited, as possible and feasible means of acquiring knowledge.

Though the poetic or artistic and the mystic experiences and perceptions cannot be denied, they are highly individualistic and cannot be replicated to form the basis of common knowledge, nor can they be validated by any means. Further, it is also not possible to analyse the experiences to

know their nature and the perceptions they generate or the sensibilities they awaken. In every society, in every culture and in every period, the two streams continue to exist, often independently, but occasionally interacting and borrowing one from another, to provide a new perception or to provide a new dimension. But in occasions when the alternative perspective of acquiring knowledge becomes an anti-science movement, a crisis then begins to occur. This happens when the State, i.e. the political rulers and the dominant elite begins to fear the new knowledge and its applications, so they launch an attack on the method of science and the context of science in order to preserve the *status quo* in society. In such a situation the alternatives are, as Farrington succinctly puts:

Either we must base our civilisation more thoroughly on scientific foundations, or we must destroy science itself. Both processes are taking place in the world today.⁴

In short, religion or religious dogmas or an ideology is used by the vested interests to mobilise people who do not share the scientific rationality, since no effort has been made to disseminate the knowledge and its rationality to them or they have been kept out of the gains of knowledge and the resultant development. A cursory look at the history of different culture would reveal such an unpalatable process.

CONCEPTUAL FRAMEWORK OF HISTORY OF SCIENCE IN INDIA: ISSUES AND PROBLEMS

European Approach

European science, it may be stressed, was a part of a movement in revolt against medieval system of production controlled by feudal nobility and the Church which controlled the intellectual climate. It was a result of effort to seek and develop alternatives to the production system as well as search for a new intellectual framework.

Agricola's (1490–1539) *De Re Metallica*⁵ gives details about mining and metals, with illustrations. He also provides economic reasons for undertaking mining as compared to agriculture and also dispels then prevalent superstitions about mining. In other words, it provides both the economic reasons as well as new outlook based not on ancient texts but on observations and experimentation. The same approach is to be found in books of Botany and Zoology and in the comments and notes of European travellers to other continents.

The techno-economic developments also engendered new social and

technological organisations—instead of craft guilds. The beginning of factory system was laid with wage labour, the concept of input and output and productivity along with it the new management system. It also created conditions for mechanical instruments such as clocks. The warfare, apart from demand for regular supply of weapons, also led to the manufacture of cannons, guns and gun powder.

The change of intellectual framework began with the challenge to authority and criticism of the established doctrines. In Art it began with realism, and a vision and perspective of nature including the study of man, its anatomy, physiology. In medicine, it questioned the authority of Galen—starting from Vesalius to Harvey.

Leonardo da Vinci (1452–1519) provides an alternative in art, architecture, engineering, technology as well as warfare. His endeavours show the range of changes both in science and technology, its methodology as well as rigorousness. In other words, in the whole range of intellectual pursuits, astronomy, mathematics, medicine, engineering, architecture, art and literature—we find a new framework and new horizons.

What is considered to be a scientific outlook, apart from developing the methodology for collecting and analysing facts and developing hypothesis, theories and laws of nature to be applied to social systems, by collecting social data, such as by Quetelet, and analysing and drawing conclusions from them. In doing so, a parallel was drawn between nature and the use of natural laws to impose them on human behaviour and social organisations. Mechanical philosophy, as it was developed in natural sciences, was applied to the functioning of society by people like Locke and others.⁶

These developments, as they differed from the productive system and ethos and the way of looking at nature of Asian countries, were effectively used to develop the framework of writing the history of science to marginalise the Asian developments of science and technology, while borrowing from Asian developments as a base of their own growth. The Europeanised Greece was adopted as a source for the development of their science and philosophy,⁷ and the developments in different branches of science, as a beginning of new science. In the writings of history of science and technology, it was made out that the story began with them. The period, after the eclipse of Greece and till the beginning of these new developments, after renaissance in Europe was called the Dark Ages. The developments and role of science in Asia from the tenth to the sixteenth and seventeenth centuries were reduced to a passive one of translating Greek science in their languages, and thus preserving it and later on passing it to Europe, where it flourished

again. This European framework of history of science requires to be discarded and the historical development of science requires to be studied in the context of cultural and social development on the one hand and the purpose it served in society on the other.

The second dimension and framework for writing the history of science as it evolved in the nineteenth century in Europe arose as a result of the development of industry. As a result of development of the different industries, with each industry developing a particular branch of science, to meet its internal needs and requirements, chronological and step wise development of each branch came to be recorded. Such a recording also developed the notion of causal and linear development, each step laying the foundation for the next chain of development. Such a picture also delinked the interconnections and linkages of scientific development with economic growth, political policies and culture of the country and the underlying philosophy which provided underpinning for the then contemporary developments in all the fields. It also helped to marginalise Asian scientific development as it had a different framework.

Growth of Science and Linkages with Cultural Areas

Often the concept of present day India (or India under the Colonial rule) is taken to cover the range of Indian scientific development. But a study of geographical regions brings out different eco-systems, historical growth of human habitation of different regions, different levels of agricultural development of different parts, the technologies of different regions and scientific development in different regions of the country.⁸

In the historical period, there were also radical changes. For instance, during the Sultanate period in the north of India, there was a break with the south, leading to some changes and innovation in cultural history, particularly through the introduction of new technologies.

The concept of nation state, which was developed along with the growth of industrialization, disrupted the concept of cultural areas, which could be applied to pre-industrial societies. Actually, when the concept of Nation State was developed it divided the growth of science and also technologies to the boundaries of the State and laid claims to the achievements of science as a part of other chauvinistic claims. If one looks carefully at the major periods of development of science, then one may notice its growth as a part of development of a culture area, flowing from the neighbouring areas. Greece, which is regarded as a fountainhead of European science, was a part and parcel of Phoenician and Egyptian culture.⁹ Its development of science

was an offshoot of the earlier developments in Egypt, Phoenicia, Mesopotamia and possibly Iran and India. References to Iranian science are found in the plays of Aristophanes and Euripides. Greek science had its distinctiveness in developing logic and working out theories about nature and natural phenomena. Greek philosophers-scientists travelled to parts of North Africa and West Asia and drew abundantly from the scientific developments and the reservoir of knowledge in these areas.

The development of science in Arabian culture area, starting from Baghdad, drew from the indigenous knowledge and heavily from India on the basis of extensive translations from Sanskrit and Pali, and also from Greece, and the extensive translations carried out of the Greek texts. Like the earlier Greek developments, it became a churning pot of the three scientific traditions viz., West Asian and North African, Indian and Greek. With the spread of Arabic culture area, with Islam as a vehicle, the Arabic science absorbed the knowledge and technologies of these countries such as Spain, North Africa and China. Similarly, when one examines the European developments, one notices the impact, not only of Greek science, but also its debt to Arabic and Indian science. Though it is only now that it is being worked out and is being accepted, the interaction of Indian science with West Asian and Central Asian culture was in existence over long periods. In fact, it would not be wrong to say that it represented one tradition. According to Irfan Habib:

Asian countries, over the centuries, had interacted with each other and exchanged ideas in different fields of science, and areas of scholarship in technology, socially and culturally as well as politically. This interaction took place through traders and travellers, through scholars who used to travel in search of knowledge, patronage, or through migration of people.¹⁰

Another feature of these developments was that along with the growth of science in a culture area, one language becomes dominant, and is accepted as the language of science. Greek, Arabic and Latin, and later on French, German and now English are the dominant languages of science.

The study of Indian science, when looked at in the context of culture area, raises many questions:

Was it totally indigenous? or had it also received and absorbed knowledge from other culture areas, i.e. outside the border of the present India? If the latter is the case then what are the inputs it received?

These related questions assume considerable significance as the scientific and related texts do not throw any light nor do they mention any sources outside India. Literature of Greece, Rome, West Africa Arab coun-

tries and Iran and Central Asia and China mention the development of sciences in India, but on the contrary there is very little mention in Indian texts of the developments outside.

Does this mean that the Indian scientists, i.e. the Brahmans who were really the scientists and custodians of knowledge, had insulated themselves from any outside influences other than the literature which they produced? If that is so, then what was the role of other groups?

We know, for instance, 'that the Buddhists travelled a lot and carried along with them the scientific and other knowledge developed in India throughout the world'. Wherever they went, Iran, Afghanistan, Central Asia or China¹¹ they disseminated Indian science. Then the question arises, was it a one sided traffic? Or they brought back to India knowledge from those countries where they had gone? And if latter was the case how this knowledge was absorbed in Indian science?

Insulation of scientists, their lack of knowledge of the growth and development of science in other countries is evident from the remarks of Fa Hien a Chinese Buddhist monk, when he came to Pataliputra. According to him, as stated by Needham, the scholars of Pataliputra were vain and considered no other country has any science: Al-bīrunī has something very similar to hold the view centuries later in his *Kitāb-ul-Hind* (written about AD 1030):

According to their own belief, there is no other country on earth but theirs, no other race of man but theirs and no created beings besides them have any knowledge or science whatsoever. Their haughtiness is such that if you tell them of any science or scholar in Khurasan and Persia, they will think you to be both an ignoramus and a liar.¹²

These are harsh words indeed, but he adds in the same passage:

If they travelled and mixed with other nations they would soon change their mind, for their ancestors were not as narrow minded as the present generation is. One of their scholars, Varāhamihira, in a passage where he calls on the people to honour the Brahmans says: 'The Greeks though impure, must be honoured, since they are trained in Sciences and therein excelled others. What then are we to say of Brahmans, if he combines with his purity the height of science?' In the former times, the Hindus used to acknowledge that the progress of science due to Greeks is much more important than that which is due to themselves.¹³

Al-bīrunī's quotation from Varāhamihira is important from two points: firstly, it brings out very clearly the recognition by ancient Indian scientists, of the Greek science and scientists. Further, one has to analyse how far this

knowledge influenced Indian science and developments. In astronomy the translation of two texts do give us an idea, but then what about mathematics, medicines and other areas.

If the contact with Greece and later on with Rome was there, then what about the contacts with West Asia and Central Asia and the influences of scientific knowledge of these areas on Indian science? According to D.D. Kosambi¹⁴ there are similarities between Iranian, Sumerian and Indian religious books and other texts, and there were many common myths. Further, the language developed became a means of intercourse over vast regions.¹⁵ Further, according to Kosambi, Hittite language had an Aryan base. He gives the example of the word Khatti 'which in Hittite may possibly be connected with Sanskrit Kshatriya and Pali Khattiyo'. The intercourse between Hittite and India, however interrupted and brief, was important in that the knowledge of iron which the Hittite show before other people. This could be two way, as is evident in presence of Indian humped bull on Hittite seals.¹⁶ As far as Iran was concerned, Indian gods Indra, Varuna, Mitra were worshipped before Zoroaster, and only Agni, the Indian god remained common. *Zen Avesta* also mentions the land of Seven Rivers.¹⁷ The Mohanjodaro civilisation was in close contact with these areas and had developed town planning, geometry, basic system of counting, weight scales and other areas.¹⁸ What was its influence on latter developments is still required to be explored. The three earliest civilisations of Egypt, Mesopotamia and Indus had one common factor—they were the 'earliest Riparian Urban Cultures and were centered round river's concerned flow through the deserts' and they show many parallel developments.¹⁹ In other words, the contact of India with Egypt, Mesopotamia, Sumeria, Iran and Central Asia and later Greece was a continuous one, since antiquity through trade, exchange of scientific knowledge and with development of culture. In other words, it represents culture area where flow of ideas and knowledge was a part of social and cultural and scientific and technical evolution.

Incidentally, this continuous interaction and linkages which was disrupted through colonialisation, when Indians began to look at these areas through Western studies and points of views, has been reestablished after India achieved Independence. A large number of Indians have gone and many have settled in the countries of Arabia and Iran. Central Asia will follow, as the region has achieved its independence only recently, and the interaction of Indian developments in science and technology has begun with these countries. This is very similar to what had happened earlier which had triggered off Arab Renaissance through the translation of Indian science at Baghdad. The other feature of Al-biruni's quotation of Varāhamihira deals

with the attainment of Brahmans in the field of science and their purity. This would be discussed later.

LANGUAGE OF SCIENCE IN INDIA

The Brahminical writings, whether in science or theology, were dealing with abstract and hence were timeless. As Kosambi has pointed out: 'Most of the surviving Indian documents are overwhelmingly religious and ritualistic.'²⁰ The writers were not concerned with history or reality. There was, according to him, another reason for not developing history. In the village life successive seasons were all that mattered and these showed from year to year little cumulative change and created an impression of timelessness.²¹

Another feature of the Brahminical writing, beside the language, is the method of writing. If science is based on observation and putting the observed data together to draw a picture and inferences from it, then the language is the means by which the picture is constructed and inferences drawn and expressed. So, what we have is a constructed world and is relevant to what Max Horkheimer had said, in so far as science is expressed in a language which also represents cultural and political construct:

The ideological dimensions of science comes to light, above all in what science closes its eyes to.²²

Further, it may also be worthwhile to quote the great Arab Sufi Saint Arabi (born AD 1165, died AD 1240) in this context. According to him:

All that is left to us by tradition is mere words, it is up to us to find out what they mean.

And the real meaning can be understood in the context of the construct and the constructs of the later generations.

Language can be expressed in the form of prose, poetry, anagrams, in the form of abbreviations, and in so many other ways to make explicit what it wants to convey, or to allude to it or conceal the meaning from others, other than those who are initiated. In the latter form it can be a means of exercise of power of men on other men. In other words, the educated and literate had an overwhelming influence over the uneducated and uninitiated.

The particular form of expression of science in the Brahminical literature was Śloka. To Al-birunī, who is a foreigner but a critical observer, it appears that the poetic form rather than clear expression is the objective:

Most of these books are composed in Śloka. . . . If the Hindus happen to get some book, which does not yet exist amongst them, they set at work to change into Ślokas

which are rather unintelligible. Since the material forms entails a constrained, affected style, which will become apparent when we shall speak of their method of expressed numbers. And if the verses are not sufficiently affected, their authors meet with frowning faces as having committed something like mere prose, and then they will feel extremely unhappy. God will do justice in what I saw to them.²³

D.D. Kosambi has something significant to say about writing in this manner:

Mathematical and astronomical works put into *kārika* form are merely memorised, but incomprehensible to the uninitiated because each number and operation is denoted by many different words which have other meaning in ordinary usage.²⁴

Regarding the use of words he corroborates Al-bīrunī, who comments elaborately on the last dimension. Further, Al-bīrunī elaborates as:

The Hindus use the numerical signs in Arithmetic in the same way as we do. I have composed a treatise showing how far, possibly the Hindus are ahead of us in this subject. We have already explained that the Hindus composed their books in Ślokas. If, now, they wish in their astronomical hand books to express some numbers of the various orders, they express them by words used to denote certain numbers either in one order above or at the same time two orders, e.g. a word meaning either or both 20 and 200. For each number they have appropriated quite a great quantity of words, hence, one word does not suit the metre you may exchange it for a synonym which suits. Brahmgupta says: 'If you want to write one express it by everything which is unique as e.g. the earth, the moon; two by everything which is as e.g. black and white; three by everything which is threefold; the night by heaven, the twelve by the names of the Sun.'²⁵

Incidentally, the Persian, Arabic and Urdu literature gave every alphabet of the language a number, and expressed even sentences by adding up the numbers of different alphabets in the sentence. For instance, *Bismillah-hir-Rahman-nir-Rahim* was symbolically expressed by 786. In other words, one could use numbers to express a sentence or a sentence to express numbers and *vice-versa*. This was probably adopted from India.

Al-bīrunī's comments bring forth two features. Firstly, in the language of poetry the metre was a major consideration rather than an explicit expression. And in the context of the society, only the initiated could fathom the real meaning. Further, the interpretations could differ. This also brings out the significance of Ibne Arabi's comments as well as the ideological content of science. The latter is also borne out by another comment of Al-bīrunī:

They are by nature niggardly in communicating which they know, and they take the greatest possible care to withhold it from men of another caste among their own people, still much more, of course, from any foreigner.²⁶

Now the question arises: was Al-bīrunī prejudiced? That Al-bīrunī was not prejudiced would be evident from his acknowledgement of the advances made in mathematics by the Indians. If not, then the developed writing method aimed at restricting the knowledge only to those whom they wanted to communicate and those they would initiate into the intricacies of the language as well as the meaning and the content of the knowledge.

Two possible explanations appear if one thinks why Indians adopted Ślokas for writing science text. Since paper technology was not developed in India, only possible way of communicating knowledge was through oral means, by memorising the text. Poetic forms are easy to remember.

Further, the caste structure, as it was developed in India, confined the knowledge to the Brahmans and it was up to them to teach it to others. In every society this practice of withholding knowledge from the people was part of political policy of the ruling class.

Another feature of the oral education system was linked to initiating the students in methods of computation, in mathematics and astronomy, rather than familiarising them with various concepts and their significance. And thus this method may have come in the way of innovative development. This dimension is also brought out by Al-bīrunī when he quotes Brahmagupta on different texts of astronomy.²⁷

This form of expression leaves out the interconnections and linkages of knowledge with other human activities. For instance we do not know why Bhāskara titled his book on mathematics after his daughter, was it the love for her, or he wanted it for her education, and use in everyday life? Other records also do not throw any light on this. Further, though we have some idea of the individual scientist's contribution, but his linkages with his contemporaries, predecessors or successors are not known. Consequently, one is not able to develop a picture of successive developments. Al-bīrunī quotes Brahmagupta and says: 'though the Siddhāntas are many, they differ only in words, not in the subject matter. He who studied them properly will find that they agree with each other.'²⁸ Another question which is significant is whether the scientists in India knew of contemporary developments taking place elsewhere and what was their influence. For example, was Bhāskara aware of Al-Khwarizmi's work on algebra brought out in AD 810? There was, as the evidence available considerable contact through various channels within the Culture area.

SCIENCE, SOCIETY AND INTERACTION

We are also aware about the relationship between the development of mathematics and the needs of the state in connection with the revenue and

tax system which both were very elaborate and complex, arising out of inheritance and division of property, town planning and architecture. While these needs may have provided the initial impetus, further development has been a matter of advancement of the subject. The linkage is however, important. According to Kosambi:

The moon with its phases sufficed for the primitive man's simple ritual. . . . This left the indispensable heritage of the lunar month, and prognostication by omens. The food producers' year is solar, which requires constant adjustment of the lunar months. The urgent need for a working almanac lay at the root of astronomy, algebra, theory of numbers, all of which, were conspicuous Indian specially Brahman achievements.²⁹

While writing of the text leaves many such questions the practice of knowledge in every day use brings out interconnections and linkages. The early life in the country was centred around agriculture and its needs, as has already been pointed out earlier, it leads to the development of astronomy, and later to astrology, when it was thought that planets affect human life, and their position could be used for predictions—and was used for purposes of recording births, marriages and deaths and other events. Apart from such needs, the kings and the social elite wanted to be certain of the possibility of success of their action, and to give the necessary confidence they looked for auspicious times. The kings had possibly another purpose also. They wanted to use astrology to impress upon the population that their actions had been ordained by gods and had their blessings. Consequently, they were necessary and just. Seasons also dictated the type of diet to be used, the period of collection of herbs, and the practice of yoga was part of the training of voice for music and in dance. The list is endless, however the point which needs to be considered is as to how far these practices lead to the further development of the subjects themselves and their theoretical understanding, and how these in turn led to the change in cultural values.

The use of knowledge in everyday life brings to surface another dimension: use of science for purposes of power to control the people. For the educated elite, who develop abstract knowledge, principles and laws and based on it the rationality for their purposes, for the common and uneducated people, they develop myths and dogmas, propagate superstitious beliefs, and create *mantras* to make them conform to their notions. This duality of belief in a society creates its own problems. The social and cultural pressures by the uneducated masses have its impact on the rationality and the scientists. History is full of names of scientists who were persecuted for promoting a common rationality. In India, the lack of availability of works,

such as those of Ajita, Carvakas and Uddalaka indicates the failure of rationality based on nature's study and drawing conclusions from it.³⁰

When Al-bīrunī came to India, he looked at Indian science differently in the context of validity and rationality of science, and he noticed the social pressures generated by masses, as a part of different beliefs, which tended to be part of scientific knowledge of the period. And in this context he says:

Therefore, you mostly find that even the so called Scientific Theorems of the Hindus are in a state of utter confusion, devoid of any logical order, and in the last instances always mixed up with the silly notions of the crowd, e.g. immense numbers, enormous spaces of time, and all kind of religious dogmas, which the vulgar belief does not admit of being called into question. Therefore, it is a prevailing practice among the Hindus *jurare in verba magistri*, and I can only compose their mathematical and astronomical literature, as far as I know it, to be a mixture of pearl shells and sour dates, or of pearls and dung, or of costly crystals and common pebbles. Both kind of things are equal in their eyes, since they cannot raise themselves to the method of scientific deduction.³¹

Al-bīrunī may not have fully realised the intermeshing of scientific thought with religious philosophy and social and cultural dimensions of science in India as it was embedded and used in the maintenance of social structure, but he does not appear to be prejudiced, as he often acknowledges the advances made in India. The scientific tradition which he had acquired was an extension of Ionian framework of observation and the Greek logical and philosophical framework that excluded myths and other common beliefs. It was based on a consistent rationality of its own. His critical remarks were directed against the acceptance of common beliefs and their incorporation within the framework of science.

Actually, the phenomenon is common to all cultures in every period. The political and social pressures exerted by the people, who are uneducated and who do not share the rationality of science are exploited to dilute the content of science or to attack science, whenever its conclusion come in conflict with the prevailing philosophy, the political interests or the social and cultural features of the elite.

A number of Al-bīrunī's remarks give an idea of the perception of Indian science by a new culture, which arose as a result of Arab Renaissance. The Renaissance itself owed much to the translation of scientific and medical and philosophical texts in Sanskrit and Pali on the one hand and on the other to the translation of religious texts and literature. Further, it is also important for the reason that Al-bīrunī's text was a major source of understanding for scholars who were to come to India to seek patronage of the kings, who had begun to establish their kingdoms in India.³² They found that Indian

science was totally integrated with the philosophical, religious and mythological views. In other words, science had a different meaning as compared to the science which was taught to them and whose conceptual and theoretical framework was different from the one they found in India. They further noted that in Indian science there was no distinction between the natural and supernatural, both were the interplay of gods, and their concept of time and space was also rooted in these ideas. The migrant scholars also noted the difference in context, form and method, as is evident from the various remarks of Al-bīrunī.

NATURE OF SCIENTIFIC LITERATURE IN ARABIC AND PERSIAN PRODUCED IN INDIA

It may be worthwhile, before the question of interaction is discussed, to briefly indicate the character of science which came into India with scholars who came to the country from Arab countries, Iran and Central Asia, seeking patronage of kings.

These scholars, aware of the development of sciences in India through the work of Al-bīrunī and others, particularly in mathematics, astronomy and also in medicine, had also absorbed the Greek scientific tradition in term of studying Greek texts, their translation, interpretation through commentaries and analysis of problems. The characteristic feature of their literature was.³³

- (1) The use of unambiguous and refined language;
- (2) Providing definition of terms used and giving illustrations;
- (3) Posing of problems and providing their solutions;
- (4) Giving examples for the students or the readers to solve;
- (5) Literature displaying Aristotelian logic and rationality based on Greek philosophy;
- (6) Literature displaying the three-fold purposes of knowledge viz.:
religious needs, agricultural requirements and meeting the everyday needs of life. In other words it was essentially directed towards practical needs, i.e. it was utilitarian.
- (7) The literature also reveals another tradition—viz., quoting of authorities acknowledging works of predecessors and discussing different points of views, also presenting views for or against a theory;
- (8) Extending the base of knowledge to cover newer area such as:
 - (a) Geography and history and writing of chronicles covering arts, crafts and various practices in different fields.

- (b) Geology, gemology and development of instruments for the purpose.
- (c) Detailed knowledge of animals and plants.
- (d) Physics specially, optics, specific gravity, magnets, etc. and the concept of motion and time. Development of instruments for measuring time.
- (9) Compilation of catalogues, Zijes, checking tables, catalogues of other astronomers. Development of instruments for the purpose;
- (10) Translation of Sanskrit text and familiarity with and adoption of many features from Sanskrit traditions; and
- (11) Religious opinion and consideration often coming in the way of and suppressing scientific opinion.

Having summarized the features, it may be worthwhile to go into some detail.

Haji Abdul Hamid (fourteenth century) wrote his book *Dastur al Bab fil, Ilmal Hisab* (1333–58) comprising five chapters, third chapter of which is missing in Aligarh collection.³⁴ He divides science into two *I'lm al Adyan*, i.e. science of religion, covering theology, *fiqah*, *Hadis* and observation of religious practices and personal laws. The second is *I'lm al Abdan*, i.e. natural sciences. He clearly indicates the use of sciences for purposes of religion, such as use of mathematics in making calculation for *Zakat* and *Sidakh*, or of geography in finding the direction of Qiblah and astronomy for working out the calendar and timing for prayers.

He gives references of twelve earlier works. The manuscript encompasses a large number of areas covering Weights and Measures, including Indian system, tables of multiplication, including multiplication of fractions, tables of multiplication terms relating to property, farming, arts and crafts, units of space and distance. It also provides examples and methods covering accounts, taxes and fines, landgrants and landed property, land measurement, salaries and scholarships and remuneration and rewards.

In other words, as the above enumeration for contents shows, all practical problems separating from the religious science, as Descartes did later. He could deal the problems without delving into religion or religious arguments and could discuss them in terms of their definition, method and logic. In fact, most interesting part of the book are few couplets.³⁵

Whenever I examined sciences through
In *Nav* (literature) and *Fiqah* (Religious science)
also there are differences

There is no agreement between two persons on one point
O *Muharrir*,³⁶ mark, I told you

In controversial matters, there is difference
 of arguments
 On that speciality, everyone said something
 different
 In mathematics I did not find controversy from any one
 I tried very much but could not see
 This is established by conviction based on proof
 Watch out so that it may not be thrown out to rigmarole.

These couplets are extremely interesting from many points. They provide us, on the one hand, with an insight into the mind of the author and, on the other, throws some light on the times he was living. Any book dealing with mathematics would have left out subject and confront dimension, brought out by this couplet.

Firstly, the point arises: as to what was the need for the author to say so? The fourteenth century, must have been a period of intense debate and the possible controversies in for a number of religious sects were in operation in every religion in this culture area. Abdul Hamid, a devout Muslim as well as a Hāji, probably wanted to distance sciences from the religious controversies, and in doing so may be, he was attempting to secularize science. The latter dimension is probable as he had separated the religious sciences, *Iʿlm al Adyan* from *Iʿlm al Abdan*.

Abdul Hamid was not alone to promote this aspect, the secular dimension of science, as we find later in the same century, Mirza Ulugh Beg, the king of Samarqand, whom Jai Singh referred to him as a peace loving Sultan,³⁷ says something on the same wavelength:

Religion disperses like mist, kingdoms are destroyed but the work of the scientist remains forever.³⁸

Obviously something significant was taking place in this century in this culture area. Was it an effort, after delinking science with religious philosophies and practices, to give it a wider base—to break the narrowness of scientific base from religious groups, the culmination of which we find in the efforts of Jai Singh in the eighteenth century when he tried to integrate the Islamic, Indian and European traditions in astronomy.³⁹

The other feature of these points out the differences in the languages; the language used in the religious affairs could be interpreted differently by different people, while the language of mathematics had no such criteria.

Finally, the most important dimension is brought out in the last couplet, i.e. it is not just belief, but conviction based on proof. While the matters of religion are matters of belief, mathematical solutions were based on proof.

He warns the reader, that these may not be thrown out for disputes and rigmarole. This reference may be towards the controversies of the period, when science and scientific theories were being subjected to find out whether they were in conformity with religious texts, and rejected if they were contrary.

A manuscript of the sixteenth-century *Saba' Samvat*⁴⁰ by Fathullah Farooqi written during the accession on the throne of Akbar, in 1556, is an interesting document. It is a mixture of astronomy and astrology and in combination with the Islamic tradition in astronomy and the Indian tradition. It looks as if it was directed to provide people with information on a number of areas. Effects of stars on the temperament and the future of children, auspicious time for marriages, choice of period for construction of houses, time for sowing and other information about agriculture, including measurement of land and description of various units are included in it. In addition, it provides method of finding the length of the day and night, duration of night and day in different seasons, causes of solar and lunar eclipses, and causes of earthquakes, which are linked with the astronomical phenomena. The conceptual framework of astronomy is Ptolemaic, but efforts appear to have been made to incorporate Indian terms in mentioning various dimensions of astronomy-astrology, example regarding the Zodiac signs, units of horoscope, spheres and mansions.

In addition to the linking of the astronomy and astrology to above-mentioned areas, it covers wide range of information on geography, physiology, anatomy, humours, fevers and properties of foods as also directions for keeping accounts.

The book, using simple language, giving definitions of terms used both in Persian and Arabic as well as Sanskrit, aims to provide knowledge to people which was considered useful, in everyday life, by the author. Further, it tends to correlate diverse phenomena, such as the time of birth, effect of seasonal temperament as well as different diseases, agriculture, house building and natural disasters. In other words, it is a book which seeks to put together the then available knowledge for the education of the people.

Another text was *Jawahar Ul Ukum Humayuni*⁴¹ by Mohammad Faddil bin Ali bin Mohammad al Miskini al Samarqandi, written during the reign of Humayun (1530–58) and as the title indicates dedicated to Humayun. The name of the book when translated into English would be Pearls of Sciences. It is one of the encyclopedias written between tenth and eighteenth centuries and covers a wide range of subjects and the aim of the book appears to provide the then existing knowledge to people.

It has a long chapter on the geography of India, giving the borders of

India, its division on climatic lines and also gives an indication of densely populated areas. It lists 27 types of minerals, corals, glass and stones, gives some idea of their features so as to enable one to recognise them and their medicinal properties.

There is a long chapter on hawks and their characteristics to enable one to differentiate between one type from the other, their diseases and cures. The chapter on different animals and birds, describes, as usual, their characteristic features, method of reproduction, curative and other properties. The interesting feature of the animals and birds mentioned which were found only in India and the habitat of each animal is given. The cases of Giraffe and Ostrich, not found in India but in Africa, are also given.

There is a chapter on anatomy and physiology which lists various bones, their descriptions, parts of the body. There appears to be some effort at classification. The latter is on the basis of functions performed, for example sense organs, food organs, genitals etc. It also divided spirit as vegetative, animal and temperament, effect of seasons on human body, general principles and guidelines on hygiene and method of regulating life. It gives details of different diseases, these are put together as diseases of different organs and methods of curing them, a brief idea of different drugs, categorised on the basis of functions they perform and gives the method of preparing various drugs. It gives the qualities of different types of foods categorizes as hot and dry, cold and dry, hot and moist, cold and moist and the manner in which the type of food affects various parts of the body.

The chapter on astronomy is a summary of the known knowledge within the framework of the Ptolemaic system. The interesting feature is the argument to prove the roundness of the earth. The chapter on mathematics covers Arithmetic and geometry, giving definitions and guide lines to calculate, and also directions for keeping accounts. There is a brief account covering the topics such as optics and alchemy.

In other words, the book is for general purpose, and also guide for layman.

In the end I will briefly mention about the manuscript: *Nuskha dar Fann: Falahat*⁴² by Amanullah Hussaini son of Mahabat Khan, a noble in the court of Jehangir. It is a book on agriculture. The book contains information on crops, different types of vegetables, fruit-bearing trees, flowering trees, herbs, various instrument for different astronomical and geographical features, as well as finding the direction of Qiblah, and also in making horoscopes.

In addition to the special treatises by scholars of the period, we have other major sources of information in chronicles of the period and memoirs

of the kings and history of the period. To mention a few—*Sirate-Feroze Shahi*⁴³ gives information on and practice of medicine, anatomy, physiology, pathology, therapeutics, establishment of hospitals, astronomy, astrology, irrigation projects and other public works undertaken. The most interesting feature is in the description of a clock—*Tas Gharyal*—and the description of transfer of stone pillar to Firozabad (Delhi). This was written in fourteenth century (1370).

Tuzuk-i-Jehangiri is a mine of information on natural history.⁴⁴ *Ain-e-Akbari* is another mine of information both on sciences as well as technology.⁴⁵

Travellers account like those of Ibne-Batuta is another source of information.

Mention may also be made about Fathullah Shirazi, who was a theologian in Iran. But when he came to India in the Court of Akbar his genius came into full focus as mechanical engineer, mathematician, an astronomer, and also as a contribution to philosophy, medicine,⁴⁶ grammar and literature. In other words, there was hardly any field to which he did not contribute. According to Abul Fazal: 'If the old books of wisdom had disappeared, he could have laid a foundation (of knowledge) . . .'.⁴⁷

He worked with Todarmal to check the accounts and reform the system. He also examined the currency and found discrepancies in the rules governing the coins that were short of weight on account of their excessive use in circulation.⁴⁸ In doing so he must have calculated the loss of weight against time, and may have developed some statistical ideas.

Mulla Mahmud Jaunpuri (1585–1651) wrote a number of books. His book *Al-Danhatul-Maiyyadahfi-Hadiquatis-Sural Wa'Maddah*⁴⁹ deals with physics—matter, form and motion, concept of time, concept of space, gravity, etc. A cursory glance at the text shows logical analysis of different points of views, nature of opinion and conjecture of different authors, and an endeavour is made to contrast these with what is observed and the deductions made from the latter.

His major work *Shams-i-Bazigah* is in two volumes. The first volume comprises three parts. The first part deals with time and space, motion, numbers, etc. The second part deals with heaven and earth. The third part on cosmology. The second volume deals with the Ptolemaic system and some of the problems it raises.⁵⁰ He also discusses the problems of moon spots. According to Abidi:

Mulla Mahmud Jaunpuri's remarks and subsequent observations by others led Mirza Khairullah Khan Muhandis, an associate of Jai Singh, to declare in his commentary on *Zij-e-Muhammad Shahi*:

We have found the orbits of the sun as well as those of all different, elliptical forms . . . when the equations are derived taking the orbits elliptical and calculating the positions, they generally conform to observation.

It maybe noted that this remark is based on observation only. There is no evidence that Khairullah Khan had any knowledge of Kepler's theory.⁵¹

NATURE OF INTERACTION

This brief description, although indicative of a few texts would give an idea of the scientific texts and their concepts. The authors who wrote scientific texts also contributed to literature, philosophy, theology and even on the religious matters of the period. However, the main point to be emphasized is that the language of the scientific texts and other topics vastly differed. The religious ethos which dominated the period also influenced these authors in looking at texts and materials, as would be evident from various remarks of Al-bīrunī, or for example Firuz Tughlaq, who got Varāhamihira's *Bṛhatsaṃhitā* translated into Persian, 'It was felt that eight chapters were not in conformity with the principles of Islam so they were omitted in translation'.⁵²

The question of interaction of the Sanskrit scholars and literature with Arabic and Persian scholars and literature requires to be worked out. This has to be done for each field of science. In mathematics, as has been mentioned earlier, the Arabic and Persian scholars were familiar with Indian literature and used it.

Akbar got *Bhāskarācārya II's* (b. AD 1114) *Līlāvati* translated into Persian to enable people to know the rules of arithmetic. But W.H. Abidi pointed out:⁵³

'But somehow *Līlāvati* could not become very popular, while *Khulāsat-al-Hisāb* of Bāhanuddin Amili was used as text. Further, he says: 'There does not appear to be much interaction between Western and Central Asia and India in geometry.' Probably the reason was different approaches.

Geometry in ancient India was basically constructional, it arose and developed with needs of rituals and cosmographic speculation'. *Tahira-Uqlidas* remained the most important text of Arabic and Persian reading scientists. Lack of development of algebra is significant during this period. Even though Umar Khayyam's poetry was known but algebra did not attract much attention. In the field of astronomy, according to Abidi: 'Ulugh Beg's *Zij*' which remained for a long time the main source of astronomical computation was translated into Sanskrit under the supervision of Akbar's scientist minister, Fathullah Shirazi, with the help of Abul Fazal, Kevalrama

Srimal's *Tara Sarini* is in fact a Sanskrit translation of *Zij-i-Ulugh Begi*. Besides the *Zij-i-Shahjahani*, there is a manuscript entitled *Zij-i-Nityanandi Shahjahani* in the Maharaja Jaipur Museum, prepared in Sanskrit by Nityananda, son of Devdatta in 1784 v.s.- AD 1727, the scribe being Gangarama'.⁵⁴ Further, 'in preparing different tables scholars could not avoid drawing on Sanskrit text, as is evident from the works of astronomer mathematician like Ghulam Husain Jaunpuri. However, this interaction could not evolve any unified principle of astronomy in India during the medieval period.'⁵⁵ The interaction in the field of astronomy has been well summed up by S.N. Sen:⁵⁶ 'In the wake of introduction of Arabic and Persian astronomical tradition into India under State patronage, there arose an effort, on the part of Hindu astronomers, to produce translations, adaptations and books of combined tradition, the combination taking mostly the form of mere addition, explanation of one through the other or regular coalescence.' This led to bilingual dictionaries and Sen lists a number of them. Further, he says, following Al-bīrunī, 'there had been sustained effort to translate Arabic and Persian texts into Sanskrit. These texts included those belonging to the school of Maragha and Samarquand, like *Zij of Ulugh Beg* *Zij-i-Ulugh Begi* and Al Qushji's *Risala dar hay'at* in Hyatagrantha.' Sen also lists a number of translations covering *Almagest*, *Tahrir-u-Uqlidas*. The same interaction also took place in developing astronomical instruments. According to Sen: 'with Arabic astronomy came astrolabe (Arabic *usturlab*, Sanskritized into *ustarlava*). . . . As the instrument grew popular in the land it began to be inscribed in Devanagiri script as well. The earliest work on astrolabe is *Yantrarāja* (1370) . . . by Jain Mahendra Suri, Court astronomer of Feroz Shah Tughlaq. . . .'

In the field of medicine there was a close interaction between Āyurveda and the Unani system. There were many possible reasons for that since both were based on similar theory. According to D.K.S. Chauhan and R.N. Singh, a number of drugs like *aphim* (Opium), *gwarpetha*, *Kesara madhkarni* (*Khurasani Ajwain*), *Mastagi* and a number of drugs which were known to Unani Hakims were introduced into Āyurvedic materia medica from ninth to fourteenth centuries.⁵⁷

A number of Persian and Arabic texts were used in Unani medicine, e.g. *Ganj-i-Budaward*, *Dastur al Hunud* by Amanullah Khan.⁵⁸ According to S.K. Misra, B.R. Bhatta, P.S.N. Bhat and R.B. Dwivedi,⁵⁹ 'thirteenth-century Muslims learnt Indian languages and patronised the development of Indian arts and sciences. There was great interplay between the main medical literature that they brought with them and the existing Āyurvedic treatises. This is evident by the differences in the versions of Persian literature

preserved in Persia and Unani medical literature written in Arabic by Indian Muslims. It was this period when the real harmonious interaction of scientific thoughts of the medical scientists from different disciplines took place and this is evidenced in the Āyurvedic literature created during this period, like that by Saṁgadhara and it was at this stage that the primary importance to the examination of pulse (*nāḍī*) was started to be given though there are Sanskrit manuscripts available attributed to Rāvaṇa, Agniveśa and Hārīta. The effect of Unani medicine in the contemporary Āyurvedic thoughts and vice versa may be taken as positive evidence of the idea of integrated medicine during that period which is maintained till date amongst Rajasthan Vaidyas'.⁶⁰

During the fourteenth century a manuscript was composed in Telengana by Muhammad bin Tughlaq (AD 1313), which contains 46 chapters and the Chapter 41 is entirely on Indian sources for the calcination of mercury, gold, silver, copper, etc. taken directly from Nāgārjuna and other yogeśwaras.⁶¹

The other areas where intensive interaction took place was the one where the information collected by scientists from local people, such as those in the area of fauna and flora, was documented.⁶² Those who collected the information gave Persian, Sanskrit, Arabic, Hindi or the names in other languages. The latter was very useful in the case of herbs used in medicine, etc.⁶³ The same applies to the area of geology, mineralogy, metals and information on arts and crafts. The other type of information was compiled about animals, particularly the hunting animals covering physiology, anatomy, habits, food required, diseases and their treatment and breeding, including breeding of specific features, regions where they are found.⁶⁴ Such an information was collected by hunters, hunting being a major sport of the period. For instance Khwaja Muhammad Yusuf bin Muhammad Raza, *Mir Shikar* of Aurangzeb compiled such information.⁶⁵

CONCLUDING REMARKS

The period, under consideration, can be said to be a period of considerable social change, in terms of social mobility, in particular of education and upward movement of lower castes.⁶⁶ This was probably due to the establishment of a large number of madrassas, which were open to all. The spread of education resulted in cutting across the social barriers. The advantage of madrassa education was taken particularly by those who were denied any social status and education to better their conditions. Ibn-Batuta, the

Arab traveller, speaks highly of one Ratan, a barber by caste, who became a mathematician and rose to a high status, when Mohammad-bin-Tughlaq appointed him the Wali of Sind.⁶⁷ In fact, the aristocracy did not like the upward movement of people and complained of Indians, and what they call low born people, rising in status and occupying high offices. For instance, according to Barani, in the last phase of Allauddin Khilji's reign high offices were held by such people.⁶⁸ Similar situation prevailed in Gujarat and in the Bahmani kingdoms.

The second feature of this period was, with the adoption of Persian as the court language and for keeping of records, a large number of Hindus learnt Persian. Bābur when he came to India found that all the revenue officers were Hindus.⁶⁹ In other words the elite came to be bilingual, judging from the number of translations from Sanskrit to Persian, and use of Persian in keeping accounts, records and court affairs. Toudermal and Fathullah Shirazi worked together on the reform of the revenue system of Akbar, so both knew Persian. Toudermal may in all probability would have known Sanskrit. Shirazi also translated from Sanskrit to Persian, indicating his knowledge of Sanskrit. The author of *Tibbe-Ferozeshahi*, as well as Bhowa's *Maddinnus Shifa Sikander Shahi* indicate their knowledge of Sanskrit. Large-scale translation of astronomical texts into Sanskrit, or the work of court astronomer of Firoz Shah, Mahendra Suri, are indicative of bilinguality of the educated elite and scholars. Siddiqui mentions instances of a Brāhman by name of Dunkar, who was a poet, scholar of both the natural sciences as well as the tradition of Muslim sciences, and one Sheikh Abdullah born in a Hindu family known for his knowledge of Sanskrit.⁷⁰ On the other side, a large number of translations from Sanskrit to Persian by Muslim scholars indicate their sound knowledge of Sanskrit. This discussion i.e., the bilingualism of the elite has not been explored and is required to be studied.

The third feature of this period was a continuous pressure from Muslim conservative Ulemas to limit education to theological teachings and bring pressure on the kings to enforce Islamic laws. While there was strong opposition to rational science, there was a counter current to understand and promote rational sciences, particularly built around the study of mathematics, astronomy, medicine and philosophy. The case of Abdul Hamid *Muharrir* has already been discussed. Feroz Shah Tuglaq's interest in astronomy and rational sciences led to their promotion through the Madrassas he established.

Siddiqui while discussing the Lodhi period mentions the interest of Sikandar Lodhi in the promotion of rational sciences. According to him: 'he

sought to overcome contemporary prejudices and investigated facts for himself in order to find out the truth.' The king was interested in different Schools of thought, and questioned the validity of age-old beliefs in case they did not appeal to reason.⁷¹ Perhaps as a result of patronage of the king a number of nobles and scholars evinced interest and promoted rational sciences. Siddiqui gives names of a few scholars, such as Azizullah who settled in Sambhal, and who introduced a systematic study of rational sciences and Sami-ud-Din Kambo who mastered rational sciences. Sikandar Lodhi's Wazir, Miyan Bhowa, was interested in sciences and humanism and whose book *Ma'dan-al-Shifa-i-Sikandar Shahi* was based on ancient Indian system of medicine.⁷²

The same attitude is found in the writings of the Moghul kings who also resisted the pressure of conservative Ulemas and promoted rational sciences.

The promotion of rational sciences in every period and in every language does not mean that people did not have religious, linguistic and cultural affiliations. They had all these linkages, but what it meant was that firstly, they were trying to overcome and fight back the onslaught of conservative religious leaders and bigots, who wanted to limit the knowledge to religious teachings. Secondly, the zest for acquiring knowledge to further extend frontiers and to observe, analyse and understand natural phenomena, in terms of its logic and philosophy, was always there and asserted itself with the State patronage or quite often without it.

In every society, culture and civilisation we notice the presence of two contrary movements and the struggle to dominate—conservative elements endeavouring to control the growth of knowledge and knowledge seekers effort to broaden the frontiers of knowledge and thus provide humanity with a new understanding of phenomena and create a new vision.

Fourth feature of the period is reflected in the personality of scholars. Unlike today when there is a high degree of specialisation, the scholars of this period were many dimensional personalities, understanding and contributing to a number of areas. The areas specialised by them were as diverse as religion, theology, literature-poetry, medicine, astronomy-astrology and so on. The knowledge they possessed, was used in their daily life as well as to teach and guide others.

The case of Fatullah Shirazi has been mentioned earlier and need not be repeated again. To give another example, let us take Amir Khusro (1253-), noble man and soldier in the army of many kings, a sufi-disciple of Nizamuddin Aulia, who was attached to him and the former was close to

him. He was also a man of letters and poet of eminence. As a great musician, he developed many *rāgās*, invented *Sitār* (*Sehtar*); but he was also well versed in rational sciences. The knowledge, which he had acquired, was reflected in poetry. For instance, in *Ijaz-i-Khusravi*, he indicates the centrality of Sun when he says:

People move around the man in authority as the earth moves around the Sun.⁷³

This is both a satire on courtiers as well as a statement about astronomical facts. About astronomy, he further says in *Qiran-al-Sa'adain*:

The movement of the earth has been linked with the time, hence the day and night, the seasons of spring and autumn. These changes constitute the source of life and comfort for the living beings.⁷⁴

Apart from the knowledge of astronomy and astrology he was also knowledgeable about the achievements of scientists of ancient India when he says in *Nuh Siphār* that Hindus were well versed in astronomy, mathematics, Physics and divination of past and future.⁷⁵

This commitment of Khusro to India, its heritage and the pride in its culture was also a beginning of laying the foundation of a new culture, as a part of the intermingling of the two streams. Khusro was not alone—from Khusro to Darashikoh and Jai Singh as well as later we find a string of personalities who aimed at and promoted what latter came to be called *composite culture* and more beautifully expressed as *ganga jamni culture*. In the creation of this culture, the Sufi movement with its ethos played some role. The Sufi movement has been studied on the basis of *Silsilhas*, i.e., various groups with their loyalty to a specific guide. It is also categorised as *Shariati* i.e., those following *shariat* and *Tariqati* i.e., those following tradition. Further, based on the temperament of the guide they have also been categorised as *jalali* i.e., with those with hot temperament or as *jamali* i.e., those with sweet temperament. Joseph Needham⁷⁶ has classified them as *esoteric* and *naturalistic*, the latter being those who had interest in science and technology. In this category mention may be made of Jabir Ibne Hayyan, the chemist, Omar Khayyam, the poet, astronomer and mathematician. In India perhaps besides Khusro, Kabir who worked as a weaver, Mahmud Shah Musafir who built the underground water system in Aurangabad and Panchakki (water mill), may be included as the naturalistic Sufis.

Irrespective of categorisation the main point which is required to be stressed is that Sufis preaching different ways of reaching god or arriving at truth, as against the shrill cry of *jehad* and only one way to reach god,

created a basis for developing a plural society, and by undertaking projects to benefit people like the work of Mahmud Shah Musafir, or through poetry like Raskhan and Rahiman or the writing of Sufis like Sheikh Mohammad who wrote in Marathi created a pluralistic cultural ethos.

The question which is to be faced now is how this ethos and the interaction between Arabic and Persian scholars and Sanskrit scholars affected science and its further growth.

However, despite the general ethos of bilingualism and plurality and the State patronage to promote interaction through the support of both Sanskrit scholars as well as Arabo-Persian language scholars, all that was achieved was the availability of translations and adaptation of knowledge of one stream with the other. Admittedly, many books had been written combining the two traditions, but an integrated simple tradition did not emerge to create a base for further development of science to a new level of development or providing a new direction.

Amongst the many probable reasons for the lack of further evolution of science, it may be worthwhile to mention a few.

1. During the period India remained an agricultural society, and consequently demands on science remained the same and no new challenges arose to create new knowledge to help solve new problems. Only two major developments were in the area of technology. Introduction of paper technology made knowledge accessible to wider section of society. Secondly, there was some development of military weaponry technology, apart from the developments of arts and crafts in a number of areas. But these developments were based on practices, improved and developed through experience, but no theoretical development took place.

2. The division between science and technology continued, despite the fact that the artisans and craftsmen gained in social status. Scientific activity and knowledge, by and large, remained a preserve of the elite, while arts and crafts remained with the less privileged groups. The result of this division was that the problems generated by technology were not attempted by scientists to widen the scientific knowledge and create a theoretical understanding of problems.

3. The pluralistic tradition of Hinduism, whereby different philosophies continued to co-exist—the most rational as well as mythological—and the pluralistic ethos created by Sufism, led to the coexistence of the two streams—Sanskrit as well as Arabo-Persian without any unified, integrated tradition. The latter process was also hampered by the continued domination of classical languages.

4. The religious prejudices and the linguistic arrogance may have also

come in the way of the evolution of a single tradition. This is despite the efforts of many to overcome these limitations and boundaries.

5. The philosophic and theoretical framework being different, the Vedic logic in one case and the Ptolemaic, the Euclidean and the Aristotelian logic in other became a major block, since both were associated with religion. The pressure of the conservatives was too much to discard the overall framework to create and develop a new integrated tradition.

6. It also appears that the two different processes remained at work during the period, one towards the integration of the two traditions and the other keeping them apart.

The counter to this liberal movement and the Sufi pluralistic tradition was led by the conservative Ulemas like Qazi Mughis during the reign of Allauddin Khilji and Maulana Abdul Qadir Badauni in the reign of Akbar. They were opposed to the Sufi pluralistic and liberal tradition and endeavoured to convert India into an Islamic State. Their counter part was the insular Brahman with his concept of his purity and the purity of knowledge, as would be evident from the remarks of Varāhamihira mentioned earlier as quoted by Al-bīrunī. Both the Mullah and the insular Brahman did not want to think beyond the *Qur'ān* and the Vedas as they thought that all knowledge was contained in the sacred text and all that was required was to understand and interpret it.

In the time of political and social unrest these people were able to reinforce their base, as they became more and more uncertain of this future. The latter was possible as the elite failed to diffuse their rationality to the people at large.

7. Lack of institutionalization of education, being organised among scholars, the continuity and accumulation of knowledge in specific institutions did not take place. With the death of the teacher, the school often dispersed.

8. Changes of Dynasties and kings with different approaches to knowledge within a dynasty also came in the way of continuous growth of institution and spread of knowledge within the institution.

Despite these factors, was there a possibility of Indian developing a unified base of science, incorporating new knowledge which was taking place in Europe? The literature of the period and the effort of Sewai Jai Singh do indicate that development in this direction was probable. However, whatever was left of the liberal pluralistic tradition and the growth of rational sciences, the possibilities which were emerging was disrupted by colonisation. The coloniser reinforced in turn to his advantage the conservative ethics and religious grouping of the people, and imposed a new scientific system in a

new language completely marginalising and delinking the earlier knowledge system from the new. The irony of situation was that they used the knowledge as well as technology for the development of their own system. That is another story.

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27. The text given in paragraph below.
28. *Al-biruni's India*, pp. 153-4.
29. *ISIH*, p. 236.
30. Kosambi, *ISH*, p. 236; D.P. Chattopadhyaya, *History of Science and Technology in India*, vol. II, Firma K.L.M., 1991
31. *Al-biruni*, p. 24.
32. *Al-biruni's India*.
33. The above summary is based on the Study of 14 Manuscripts in Arabic and Persian starting from fourteenth to eighteenth century.
34. Maulana Azad Library, Aligarh.
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37. Vide G.R. Kaye, 'Astronomical Observations of Jai Singh', Calcutta, 1918. Actually it is from the translation of the Introduction of *Zije-jadid, Mohammad Shahi*, by Jai Singh.
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39. See A. Rahman, *Maharaja Sewat Jai Singh and Indian Renaissance*, Delhi, Navrang, 1987.
40. Lytton Collection, Maulana Azad Library, Aligarh.
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42. Lytton Collection, MSs no. 91, Maulana Azad Library, Aligarh.
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57. *IJHS*, 16(1), 1981, pp. 17-21.
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65. *Dastur-us-Said*, Mss no. 7991/1, Subhanullah Collection, Maulana Azad Library, Aligarh.
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67. Ibid., pp. 26-8.
68. Ibid., The text indicates it, also see *Hamdard Islamicus*, vol. X, no. 3, 1987, p. 75.
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70. I.H. Siddiqui, *Islamic Learning and Intellectual Thought in Sultanate of Delhi during the Lodhi Period: Hamdard Islamicus*, vol. X no. 3, 1987, p. 75.
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72. *Hamdard Islamicus*, loc. cit., p. 74.
73. Loc. cit., p. 60.
74. All these quotations are from Masnawi *Nuh Siphir*.
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Advent of Western Medical Education in India

O. P. JAGGI

PORTUGUESE MEDICAL SCHOOL AT GOA

The old town of Goa began showing greater signs of insanitation in the last decade of the sixteenth century. Its large population of 400,000 inhabitants lacked proper sanitation and medical assistance and was decimated by deadly epidemics. As a result of that, in 1670, population was reduced to 40,000. From the Viceroy D. Garcia Noronha, who died in 1540 of 'the bed-chamber sickness' (dysentery) to the Count of S. Vincente who died of typhoid in 1600, ten Viceroys and Governors died in Goa. According to Frei Diogo de Santana, 25,000 soldiers died in the Royal Hospital between 1602 and 1632.

This grievous situation of death and disease led the Viceroy D. Cristovan de Souza Coutinho to address the following appeal on 8 December 1687, to the State Secretary for the Overseas: 'If two or three masters had come to this State, they would have taught physics to many of the natives, who are very quick-witted and have the gift of learning and would not be of the worst, and so that the hospital would have many doctors to help cure the diseases of your Majesty's Vassals'.¹

From such appeals resulted the rudimentary teaching of medicine at the Royal Hospital beginning in 1703 with Cipriano Valadares as the Master. This type of training continued when in 1801 Miranda and Almeida started a three-year course of medicine and surgery at the Military Hospital of Goa, situated at Panvelim. In 1821 this course was extended to four years.

On 5 November 1842, the Goa Medical School was founded at Panjim

on the style of the Continental Medical School of Portugal and France. The teaching programme was spread over four years. In 1846, the first batch of eight students passed out. In 1847, the course was extended to five years and the school was named as *Escola Medico-Cirurgica De Nova Goa*—the School of Medicine and Surgery of New Goa. In 1871, the staff was increased by the addition of seven more lecturers, of which three were graduates of this very medical school. In 1881, in addition to the existing syllabus, a course of Midwifery, Gynaecology and Pediatrics was added. On the 25 January 1888, an ordinance was passed, which converted the existing school into a Naval and Colonial School of Medicine.

The doctors trained in the School of Medicine at Goa were particularly useful during the colonial campaigns and sanitation of the Portuguese overseas territories. In 1854, the Mozambique Board of Health had a doctor from Goa Medical School, in 1856 the Timor Board, in 1863 the Board of Angola, in 1866 that of St Tome and of Cabo Verde, in 1870 Nacau and in 1880 of Portuguese Guinea.

As early as in 1818, Fonseca Torric, Director of the School, stated that out of 67 physicians in the Portuguese overseas territories, 43 had qualified at the Goa School. He also said that the physicians of the Goa School were intelligent, good doctors, and had profound knowledge of tropical diseases. About these Goan doctors, Pedro Joisquim Peregrino de Casta wrote: 'In the sanitary campaigns, the fight against epidemic, in the anti-smallpox vaccination serviced only then begun . . . the work of the doctors of the School of Goa is of the utmost importance and is patent in some of the reports published in the medical statistics of the hospitals and reports of the Overseas Provinces Health Services'.²

In 1946, the School was made autonomous and re-christened as *Escola Medicina Cirurgica de Goa*, no longer under the control of the Health Services.

FIRST BRITISH MEDICAL SCHOOL IN INDIA

After the middle of the eighteenth century, the British surgeons in charge of hospitals, trained a few Indians on the general aspect of diseases and on European modes of treatment. This training, however, was not systematic. These trainees were called 'native doctors' and were recognized as such by the government who appointed two to each regiment and one or more to each civil station. The native doctors commenced their careers as compounders and had to submit to examinations before they were entitled to higher rank and pay.

The earliest definite regulations on the subject are those issued in the General Order of 15 June 1812, directing the training of European and Eurasian boys to form a sub-medical service for the army. Indians, however, were not admitted to this class.³

The demand for such trainees gradually increased and it was found necessary to establish an institution where a more uniform and better system of education could be imparted. The Medical Board addressed a memorandum on the 9 May 1822 to the Secretary of the Government of India in the Military Department, in which this matter was placed and laid stress upon. The proposal of the Medical Board was approved by the Government in nearly every particular and published as a General Order dated 21 June 1822. The G.O. laid down that in this institution, 20 Indian students should be admitted and that they be recruited by the Superintending Surgeons. The Superintendent of the Institute was directed to translate medical books and to instruct the students in the vernacular languages. The students were to receive a stipend of Rs 8 a month during their education. After qualifying if they entered government service, they were required to serve the Army or Civil department for 15 years and were to receive a salary of Rs 20 per month with an extra allowance of Rs 5 when on field service. Surgeon James Jamieson was appointed the first Superintendent of his native medical institution on a salary of Rs 800 per month, and was allowed a *munshi* at Rs 60 per month, writer at Rs 30 per month and a peon at Rs 5 per month. On the death of Surgeon Jamieson, Surgeon Bretton took charge in June 1823. In April 1824, the government sanctioned printing of a vocabulary of medical terms in the Roman, Persian and Nagari characters. A Pundit was appointed to assist the Superintendent in his work. On 10 June, a sum of Rs 709.3.9 was sanctioned for the purchase of two skeletons from Messrs Bathgate and Co. The *London Pharmacopoeia* was translated in March 1825. The school opened in October 1824.

The Sanskrit medical classes were located at the Calcutta Sanskrit College and the Urdu classes at the Calcutta Madrasa. Instruction was imparted through the medium of the Sanskrit or Urdu languages by translating short treatises on different subjects. The following books seem to have been translated and lithographed at government expense: Hopper's *Anatomist's Vademecum*, Surgeon's *Vademecum*, Thomson's *Conspectus of the Pharmacopoeia*, Fyfe's *Manual of Chemistry*, and Conquest's *Outline of Midwifery*, *Tropical Diseases* by Twining and Smith, *Plague* by Dr Thomas and some books on vaccination. Pandit Madhusudhan Gupta was paid Rs 1000 for translating Hooper's *Anatomist's Vademecum*.⁴

The period of training at this school lasted three years. In the first or

junior class, Pharmacy, *Materia-Medica*, Physiology and Anatomy were taught. Medicine and Surgery were taught in the two senior classes. For clinical teaching, the students were required to attend the Native Hospital, the General Hospital, the Hon'ble Company's Dispensary, the Branch Dispensaries at Colingah and Gurrinhatta, the Eye Infirmary, and the Department of Superintendent of Vaccination. Dissection of the human body was not, however, performed and the only practical information given on the subject was obtained from the dissection of lower animals and from the post-mortem examination at the General Hospital which the students of the Native Medical Institution were permitted to witness. In the medical classes at the Sanskrit College, the works of Caraka, Suśruta and other old Hindu writers were studied, together with medical treatises in Urdu which had already been prepared for the students of the Native Medical Institution in the medical classes at the Madrassa, the works of Avicenna and other physicians of the Arabic school were studied in addition to the same Urdu treatises. Some of the Arabic books studied were *Sharah Asbab*, the *Aksuræ*, the *Sudede*, the *Kanunchah*, and the *Anees ul-mosharra* being translation of Hopper's *Anatomist's Vade-mecum*.⁵

The method of teaching adopted in the School is described in a report submitted by Dr Bretton to the Medical Board in April 1826. Some extracts from it are as follows:

The system adopted for the tuition of the students is this: Thursdays and Sundays are appropriated to the giving of lectures on any subject previously prepared in Hindustani, to the performing of experiments of any kind, to the preparing of different substances such as sulphate of soda, magnesia, muriatic and nitric acids, calomel, hyd, precip-rubrum, caustic bougies, spirits of wine from rice and *gur* and distilling the same, and to the purifying of substances by sublimation as benzoin, camphor and sulphur.

When not engaged in these operations, the students are made to read the Pharmacopoeia and Ramsay's *Materia-Medica*, and to explain every part they read. This plan enables them to comprehend thoroughly the compounding of every article enumerated in the Pharmacopoeia, and will conduct to the medical officers and native doctors rendering themselves intelligible to each other in the preparing and dispensing of medicines.

Every Monday, Wednesday and Friday night from 8 to 10 o'clock, the students are convened and made to read the medical tracts prepared for them. The seniors are each made to describe from memory before me and two of my assistants the component parts of the brain, viscera, bowels and structure of the eye, and to answer such medical questions as may be put to them. This keeps their minds constantly exercised and impresses thoroughly in their recollection what they see and learn, and the other pupils are made individually to read medical tracts, etc., before the

other assistants and four of the capable students, who as monitors, assist in keeping every one present fully exercised.

Dr Bretton went on to say: 'I have recently been able with the apparatus in my possession to show the students a variety of experiments with the air pump, and on electricity. These have given them a little insight into the properties of air and the phenomena of lighting, of which they had not the remotest conception, and serve to render their studies more pleasing than irksome.' Dr Bretton noted that 'the zeal and diligence with which the pupils prosecute their studies even in the least attainable part i.e. Anatomy, afford a very cheering prospect of their ultimately becoming one of the most useful class of servants in the service of the British Government in India.'⁶

The students of the Sanskrit medical class displayed considerable knowledge of Anatomy and Physiology. Some of the successful students were appointed to responsible positions under the Civil Surgeons, or in hospitals.

At this time, a conflict arose as to whether the teaching in medicine should be imparted in the vernacular or in English. Dr Tytler who was a versatile oriental scholar and who had translated many European tracts into the vernacular for the teaching of students, maintained that the education of Indian students should be given in their own vernacular if possible, and that the English language should not be thrust on them, though he felt that instruction thus imparted remained of a rudimentary character. Anatomy was very imperfectly taught from plates and models and it was thought that the vernacular medium did not further advance study and assimilation of the great treatises of European medicine

In October 1833, Lord William Bentinck, the Governor-General of India, appointed a committee for the purpose of 'improving the constitution and extending the benefits of the Native Medical Institution, and suggesting a system of management and education calculated to give effect in both of these respects to the wishes of the Government'. The Committee presented a lengthy report on 20 October 1834, in which, while they acknowledged the merits of the Native Medical Institution, they also summarized its defects in the following terms: (1) absence of a proper qualifying standard of admission; (2) scantiness of means of tuition; (3) entire omission of practical human anatomy in the course of instruction; (4) want of regularity at the time of admitting students; (5) want of means and appliances for the convenience of private study; (6) desultory character of the students' attendance; (7) inconclusive nature of the power and authority wherewith the Superintendent was vested; (8) mode of conducting the final examination. Detailed recommendations were submitted to remedy these defects. On the

important point of medium of instruction, the members of the committee were divided in opinion. The Anglicists finally prevailed over the Orientalists and it was emphatically laid down that 'a knowledge of the English language we consider as a *sine qua non*, because that language combines within itself the circle of all the sciences and incalculable wealth of printed works and illustrations, circumstances which give it obvious advantages over Oriental language in which are only to be found the crudest elements of science or the most irrational substitutes for it'.⁷

The recommendations of this committee were comprehensive and radical. The committee advised immediate abolition of the Native Medical Institution and the medical classes at the Sanskrit College and at the Madrassa, and suggested the formation of a Medical College for Indians, in which various branches of medical sciences cultivated in Europe should be taught on the most approved European system.⁸

The recommendations of the Committee were approved and the foundation of the Medical College from 1 February 1835, was sanctioned in General Order No. 28 of 28 January 1835. The Native Medical Institution and the medical classes at the Madrassa and at the Sanskrit College were thus abolished.

FIRST MEDICAL COLLEGE IN CALCUTTA

In the General Order of 28 January 1835, the Governor-General of India Lord William Bentinck was pleased to pass the following resolutions: (1) That the Sanskrit College medical class, the medical class of the Madrassa, and the Native Medical Institution be abolished from the first proximo. (2) That such of the students of the Native Medical Institution as are now capable of passing their final examination, shall be appointed native doctors, and all the other students of that institution be transferred to the native corps of the Army, upon their present salaries, to become native doctors when represented to be duly qualified by a committee of medical officer or if not found qualified in two years, to be discharged. (3) That a new college shall be formed for the instruction of a certain number of native youths in the various branches of medical science. (4) That this college shall be under the control of the Education Committee. (5) That the Education Committee shall have the assistance of the following medical officers, *ex-officio*: the Surgeon of the General Hospital, the Surgeon of the Native Hospital, the Garrison Surgeon of Fort William, the Superintendent of the Eye Infirmary, and the Apothecary to the Hon'ble Company. (6) That instruction be given through the medium of the English language. (7) That a certain number of

native youths whose ages shall not exceed twenty years or be less than fourteen years, shall be entered upon the foundation as foundation pupils of the institution. (8) That all candidates for admission as foundation pupils be required to present respectability of connections and conduct, shall be able to write and read English and Bengali or English and Hindustani, and with these qualifications all natives between the age of fourteen and twenty shall be equally eligible without exception to creed or caste. (9) That the candidates shall be examined by the Education Committee and the Superintendent of the institution, and that the selection of the pupils shall be determined by the extent of their acquirements. (10) That the number of the foundation pupils shall be limited to fifty. (11) That the foundation pupils shall each receive a monthly stipend from Government of Rs 7, which may be increased according to the following scale. That all foundation pupils be divided into three classes, each class having a different salary: the first class, Rs 7 each month; second, Rs 9; third, Rs 12. (12) That the formation of these classes shall be entrusted to the management of the Education Committee and the Superintendent of the institution, it being distinctly understood that the classification will depend upon the acquirements of the pupils, and not upon the periods of their studies; excepting, that no pupil shall during the first two years of being on the foundation, receive a salary higher than Rs 7 per month, but afterwards the increase will depend upon the classification. (13) That the foundation pupils shall be expected to remain at the institution for a period of not less than four years and not exceeding six years. (14) That all foundation pupils be required to learn the principles and practice of the medical science in strict accordance with the mode adopted in Europe. (15) That all the pupils who shall have completed their studies according to the form prescribed, shall be entitled to have certificates signed by the Superintendent to enable them to present themselves for final examination. (16) That the final examination for granting certificates of qualification to practise surgery and medicine, or for admission into the Service, shall be publicly made by the Committee of Education, assisted by the medical officers above mentioned. (17) That such pupils as shall be deemed qualified to practise surgery and medicine shall receive certificates of qualification signed by the President of the Committee of Education and counter-signed by the Secretary of that Committee and the Superintendent of the institution. (18) That the public service shall be supplied with native doctors from the institution, and with a view to this object, whatever appointments may happen to fall vacant during the period which intervenes between two examinations, shall be offered for the acceptance of the students who passed at the examination next ensuing.

The selection shall be regulated by the extent of professional acquirements. (20) That as an inducement for pupils of a respectable class to enter the institution, the pay of the native doctors who shall have been educated at the college and have received the certificates of qualification, shall be Rs 30 per month; after seven years' service their pay shall be Rs 40 per month, and after fourteen years, Rs 50 per month. After twenty years' service they shall be entitled to retire upon a pension regulated according to the proportions granted to native commissioned officers of the army, if no longer capable of performing duty from age, disease or wounds. (21) That the education committee shall be charged with providing a suitable building for the college, a library, anatomical preparations, and all other objects of indispensable necessity for the education of the pupils, the expense being previously submitted for the sanction of the Council of India. (22) That the college shall be under the management of a European Superintendent who shall devote the whole of his time to the interests of the institution and who shall not be permitted to enter into private practice, or to hold any situation that can in any way withdraw his attention from his duties at the institution. (23) That the Superintendent shall be permitted to draw a staff allowance of Rs 1,200 per month in addition to his regimental pay and allowances. (24) That the Superintendent shall be aided in his duties by a European assistant who shall draw a staff salary of Rs 600 per month in addition to his regimental pay and allowances. (25) That the European assistant shall devote the whole of his time to his duties at the institution, and that he shall not be permitted to enter into private practice, or to hold any situation that can withdraw his attention from the interests of the institution. (26) That the European assistant shall exercise no control over the management of the institution, excepting by permission of the Superintendent, but that he shall confine himself to the duty of assisting the Superintendent in the work of educating the pupils. (27) That the whole management of the institution, the charge of the pupils, the mode of teaching, and all the arrangements, shall be entrusted to the judgement and guidance of the Superintendent under the control of the Education Committee. (28) That the Superintendent shall make half-yearly reports on the state of the institution to the Education Committee, by whom these reports shall be forwarded with their sentiments to the Government of India. (29) That the division of duties of the Superintendent and of the assistant, shall be made at the discretion of the former, subject to the control of the Education Committee. (30) That the Superintendent with the aid of his assistant shall be expected to instruct the pupils in Anatomy, Surgery, Medicine and Pharmacy, and to qualify them for medical charges, either civil or military. (31) That the pupils shall visit to witness the practice,

the General Hospital, the Native Hospital, the Hon'ble Company's dispensary, the dispensaries for the poor, and the Eye Infirmary. (32) That the Superintendent shall be supplied, under the direction and management of the Education Committee, with a certain monthly allowance of stationary for the use of the institution. (33) That the formation of a plan of medical education and the rules and discipline of the institution shall be entrusted to the Education Committee. (34) That in addition to the pupils in the foundation, the benefits of this college shall be open to all classes of native youths between the age of fourteen and twenty, without exception to creed or caste, provided they possess respectable connections and conduct, and can read and write English and Bengali or English and Hindustani, and that all thus qualified shall, at the discretion of the Education Committee, be permitted to attend the instruction at the college, subject to its discipline and regulations. (35) That the Superintendent shall draw a pay bill for the establishment of the institution, which shall be counter-signed by the Secretary of the Education Committee, and shall annex to it a nominal roll of the youths on the foundation and voucher for the payment of the house-rent, both signed by the Secretary of the Education Committee.

The Governor-General nominated Assistant Surgeon M.J. Bramley to the post of Superintendent of the new medical college; his appointment took effect from the 1 February 1835. The premises previously occupied by the Petty Court Jail, an old house situated in the rear of the Hindu School, were converted for the use of the newly started Medical College. The books and apparatus of the abolished Native Medical Institution were handed over to the college. Pandit Madhusudan Gupta who was a *Vaidya*-teacher at the former institution was transferred with two assistants from the Sanskrit College. Assistant Surgeon H.H. Goodeve was appointed as Assistant to the Superintendent on a salary of Rs 600 per month. By General Order No. 10, dated 5 August 1835, the official designation of the Superintendent was changed to that of Principal, and that of his assistant to Professor of Medicine and Anatomy. Shortly afterwards, a third professor, that of Chemistry and Materia Medica was added to the staff and Assistant Surgeon William B.O. Shaughnessy was appointed to the post.

The Medical College opened on 20 February 1835. At the time, there was no library, no museum, no hospital, no 'philosophical' apparatus. Anatomical models were procured from England including two skeletons which were purchased through Messrs Bathgate & Co. of Calcutta at a cost of Rs 1500. Mr Evans was appointed as curator to the newly-established museum.⁹

The teachers of the college were faced with the task of combating a

strong national prejudice against the study of anatomy or dissection. This prejudice was so deep-rooted among the larger section of the community that their contemporaries laughed at the attempt to introduce it with scorn 'as a vain chimera', while the best of their friends assisted them 'with a very modified degree of encouragement, uncertain of the propriety of committing themselves to approve of what appeared, at best a very doubtful experiment'. To overcome this prejudice, parts of the human body were first introduced in illustrations at the daily instruction and these gradually replaced the sheep's brain, goat's liver, wooden models and tin representations, which formerly served the purpose of teaching anatomy. It took six months to institute the required course of anatomical lectures. When Dr Goodeve first placed an entire dead body on the lecture table, it created much interest, and some excitement among the pupils. They, however, very soon became accustomed to it.

Madhusudan Gupta, earlier *Vaidya*-teacher in the Native Medical Institution, on 10 January 1836, accompanied by four pupils, namely, Uma Charan Set, Dwaraka Nath Gupta, Raj Kristo Dey, and another whose name is not available, is said to have gone with Dr Goodeve to an out-house of the building. Madhusudan dissected a body which had been procured for a lecture-demonstration. Gradually other students also made bold in dissection of the human body. Dr Goodeve while delivering his introductory lecture in 1838, remarked: 'In less than two years from the foundation of the college, practical anatomy has completely become a part of the necessary studies of Hindu medical students as amongst their brethren in Europe and America. The practice of dissection has since advanced so rapidly amongst us that the magnificent rooms, recently erected, in which upwards of 500 bodies were dissected and operated upon in the course of the last year, have already become too small for our purpose; we have been compelled to construct an adjoining shed for the convenience of the class, now amounting to upwards of 250 youths of all nations, colours, religions and castes, co-mingling together in this good work as freely and amicably as the more homogeneous frequenters of an European School'.

The first final-year examination was held on the 30 October 1838, after three and a half years' study. Each candidate had attended three courses of anatomy and physiology, two of actual dissections, three of chemistry, one of natural philosophy, two of materia-medica, two of general and medical botany, two of the practice of physics, two of the principles and practice of surgery and one of operative surgery. The examiners thought that this amount of instruction was sufficient to embrace all the essential branches

of a complete medical education, with the exception of midwifery, for the teaching of which there was no provision at that time.¹⁰

The remarks of the examiners about the examination were expressed as follows: 'The ordeal through which these young men have passed is one of no common kind, and affords a very gratifying measure of capacity and acquirements. The result is such as to satisfy us with their average-knowledge of a solid and well-ground character. We have unanimously come to the decision of granting them letters of testimonials, and we consider them competent to practise medicine and surgery. We beg to recommend them according to the liberal consideration of the Government as the first Hindus who rising superior to the trammels of prejudice and obstacles of no ordinary character, have distinguished themselves by attaining to complete medical education upon enlightened principles. We consider Rs 100 per month at the outset of their service as the most suitable rate of remuneration which might be increased in progress of time according the extent of the service and desert.'¹¹

The government approved of these results and accordingly a meeting was held in the College theatre presided over by Sir Edward Ryan, the then Chief Justice and President of the General Committee of Public Instruction, for the purpose of conferring letters of qualifications on these young men. A large number of European and Indian gentlemen were present. Prizes presented by Dwaraka Nath Tagore were also awarded to the successful students at the conclusion of the ceremony. Uma Charan Set stood first and was honoured for his distinguished career with a gold watch presented by H.E. Lord Auckland. These four students were without delay appointed as Sub-Assistant Surgeons to the hospitals at Dacca, Murshidabad, Patna and Chittagong at Rs 100 per month.

In 1845, the course of teaching at the Medical College was extended from four to five years. The Medical College gave a diploma in medicine and surgery, until the Calcutta University was founded in 1857, and granted the degrees of M.D. and L.M.S. (Licentiate in Medicine and Surgery). The degree of M.B. was subsequently added. For many years the Calcutta University granted two qualifications to the Medical College students at the end of an under-graduate course of five years, viz., L.M.S. and M.B. At that time the students aimed at obtaining both the qualifications, but the majority only succeeded in obtaining the licence.

By 1860, the Calcutta Medical College was well-equipped with an anatomy department, a museum, a laboratory and a large hospital in which every form of disease, medical and surgical, could be seen and studied. According to

the *Indian Medical Gazette*. 'Few European Schools of Medicine present so many and so favourable opportunities of study to the student'.¹²

An unpalatable feature of this time was the low pass percentage of the students.¹³ One of the reasons of the high percentage of failure was the poor knowledge of English. The students failed to grasp the subject and to express themselves in English. Furthermore, the knowledge of physical and biological sciences was not essential for entrance to the college. That was one of the major reasons for the students not being able to pick up medical subjects which were based on the fundamental knowledge of physical and biological sciences. Looking at this grave deficiency, the *Indian Medical Gazette*, in 1869, stated:¹⁴ 'It is impossible to over-estimate the surpassing importance of primary education in all the professions. But in none is this more essential than in medicine. Neglect this and the professional superstructure, subsequently erected, is always insecure from want of a solid and substantial foundation. It, therefore, behoves those who are responsible for the medical education of the youths of India, to look this question of defective primary instruction, in natural and physical science, in the face, and to make such representations to the authorities, as may be needed for its rectification. For it may be safely said that it is unreasonable to expect the medical students of India to assume, in large numbers, the highest position attainable in the noble and honourable profession of medicine, until their preliminary or primary education has been elevated to the standard of excellence received in Europe and America.'

How was life in general in Calcutta Medical College? An old student of the military medical class gave a glimpse of ragging when he reminisced about his experience as he entered the Medical College in 1880s. He said:

The session used to begin on the 15 June and I joined as a military student in the year 1880. I was cordially received by the older students in the military student's range, which stood on the site now occupied by the Pathological Department. I was given a hearty breakfast, doubtless to disarm any suspicions I might have as to what awaited me. After this two stalwart students armed with thigh bones conducted me before a tribunal seated round a table under which I spied a heap of boots and shoes and an enema syringe. I was asked many questions, but the most important one was whether I was willing to pay my footing of Rs 4 and abide by the established rules of the student's range. On giving my assent, I was congratulated and marched out, but woe betide the bold freshmen who refused. Our students' tribunal, like of the Holy Inquisition, understood the moral effect produced by an examination conducted in sight of the instruments of torture, and the horrid suggestion conveyed by the articles I had glimpsed under the table doubtless helped many a timid one to make up his

mind. If still recalcitrant, the tribunal was quite prepared to resort to extreme measures in the interests of discipline.¹⁵

MADRAS MEDICAL SCHOOL AND COLLEGE

A medical school was established at Madras, by General Order of 13 February 1835, during the Governorship of Sir Frederick Adam. Classes began in July 1835. The school buildings, erected at a cost of Rs 9861, were opened in July 1836. The school was established for training subordinates for the medical services in the army. The first batch of eleven 'locals' and ten 'Eurasians' were admitted for a four-year course at this institution, and after qualifying, the Eurasians were employed as 'apothecaries' and the locals were designated as the 'dressers' in the army. In 1838, the school was thrown open to the civilians, but the prejudices against Western medicine ran so high at the time that for eight years, no civilian came forward to register. When some of the civilians finally joined, it was decided to conduct three different courses, one for physicians to extend over a period of five years, another for apothecaries to run for a period of over four years, and a third for training the dressers for over three years.¹⁶

By General Order No. 92 of 23 April 1847, stipendiary civil students were admitted to go through a course of five years to qualify for the grade of Civil Sub-Assistant Surgeon. The Madras Medical School thus came on a level with those of Calcutta and Bombay, though the name was not changed to Medical College until 1 October 1850. The first batch of these civil students qualified in 1852 and were the first to receive a diploma from the college.

In 1855-56, the course of instruction given at Madras was recognised by the Royal College of Surgeons, London. In 1863, the Madras University, which had been constituted by Act XXVII of 1857, claimed the exclusive right to give medical degree and diplomas, and the power of granting diplomas was withdrawn from the Medical College, except as regards the students already under instruction.

By General Order No. 6 of 11 January 1875, female students were admitted for instruction. This was really remarkable when we take into consideration that not only in India but even in other parts of the world, medical training for women was more or less frowned upon. In the same year L.M.S. Degree course was started.

By 1885, after half a century of the existence of this institution, Madras Medical College had trained 1523 Indians and Europeans for the subordi-

nate medical service, of whom 24 became graduates of the college. In that year, it had a staff of fourteen professors and lecturers and four assistants. In that year, religion-wise the students numbered as follows: Europeans and Eurasian Christians 82, Native Christians 40, Brahmins 33, Lower Caste Hindus 49, Mohammedans 8, Parsees 3.¹⁷

GRANT MEDICAL COLLEGE, BOMBAY

In 1835, Sir Robert Grant, then Governor of Bombay, decided to establish a medical institution in the city for the natives of the province. Experienced European medical officers in the districts of the Presidency were consulted about the working conditions of the native medical practitioners—especially whether any prejudice existed against the Western system of medicine. There were two opinions on this. Some anticipated great resistance to the introduction of the Western medicine on account of the local prejudices, and some others 'questioned the aptitude of the youth of India to attain the necessary acquirements'. Others believed that 'it was vain to talk of prejudices on the part of the people of this country against the European system of medicine'. They said 'as a general principle, man in a state of suffering will court relief and accept it readily from whatever hand it comes and under whatever name it may be presented to him. The system which best cures disease and alleviates suffering, it matters not what its name may be, must be the most acceptable to people of all castes and creeds of all countries. So long as such a healing art is taught in this place, there can be no question of the ultimate success and usefulness of such a medical school.'¹⁸

This controversy went on for about two years. The success of the Calcutta and Madras Medical Colleges had by now exposed the fallacy of the imagined difficulties and adverse opinions expressed by some. Consequently Sir Robert Grant drew up a plan for starting a medical institution, the leading idea being 'to give to the people of Western India a practical and well-trained body of medical practitioners who by the skilful and conscientious exercise of the art, would so recommend themselves to their countrymen as in time to take the place of *hakeems* and *vaid*s, who for want of adequate education, must necessarily be incompetent to exercise the healing art with safety and success'.

This plan was forwarded in the middle of 1838 to the Governor-General of India for sanction. It received due sanction by Lord Auckland. But before this news reached Bombay, Sir Grant died on 9 July 1838. A public meeting of the citizens of Bombay was held at the end of July 1838, to mourn the death of one who had endeared himself to all by 'purity of his administration,

splendour of his talents, vast amount of good he had achieved, excellence of his private character, sincerity and dignity of his pity, and the very overstrained efforts under which he sank'. A fund was started at this meeting for the public commemoration of Sir Robert Grant on condition that with its aid a medical college 'so ably planned and so zealously advocated by him', should be established and that it should bear his name. The Government okayed this proposal and the foundation stone of the building was laid by Lord Bishop of Calcutta on 30 March 1843. The building was completed in October 1845 and the college formally opened by the then Governor, Sir George Arthur, on 3 November 1845.

The students were admitted to the College without consideration of caste and creed. The candidates were to be aged between 16 and 20. In addition to a knowledge of English grammar, their vernacular, and arithmetic as far as the Rules of Proportion, they were supposed to possess a thorough knowledge of English so as to be able to read and write it with accuracy and fluency. Each candidate was also requested to present a certificate of good conduct from the head-master of the school in which he had studied, and also one expressly stating that he possessed necessary qualification and was capable of taking the examination.

The entrance examination was conducted by the superintendent and the professors of the college. Of the total of 29 candidates (inclusive of a Portuguese and 3 Parsees) who appeared for examination, 12 were found qualified for entrance to the college.

The syllabus of study which was laid down by the college authorities in 1846, was formally sanctioned by the Education Board and publicly notified in the Government Gazette. According to this notification, chemistry, anatomy, the Institutes of Medicine (including the principles of physiology, pathology, therapeutics), materia medica, pharmacy and elements of botany were to be taught in the first three years of study, and surgery, practice of medicine, midwifery and medical jurisprudence during the fourth and fifth years of the course.

On the affiliation of the college to the Bombay University in 1860, the college entrance examination was abolished and from 1861, the matriculation—a rather severe and exacting examination then—was made the obligatory qualification for admission into the college.

For the clinical instruction of medical students admitted to the newly established Grant Medical College, the original idea of Sir Robert Grant was to employ the then existing Native General Hospital of Bombay for the purpose. This idea was soon abandoned when Jamsetji Jejeebhoy, a business magnate of Bombay, touched by the tragic plight of the sick, offered to

pay through Sir Herbert Compton, into the Government Treasury, a sum of Rs 1,00,000 in order to facilitate the establishment of a large hospital with about 300 beds in the city of Bombay, 'for the relief of the sick native poor of all denominations'. His generous offer conveyed to the Bombay Government in a letter dated 13 April 1838, was gratefully accepted. The government agreed to Jamsetji's term of contributing an equal amount to the Hospital Fund and to grant interest at the rate of 6 per cent on both contributions.

It was decided to build a new hospital, to be designated as the Jamsetji Jejeebhoy Hospital in close proximity to the Medical College and with an accommodation for 300 sick individuals. The foundation stone of the J.J. Hospital, containing a silver plate inscribed with the following caption over it was laid by the Right Worshipful Provincial Grand Master, Dr James Burns, on 3 January 1843, with full masonic honours in the presence of Sir George Arthur Bart, Governor of Bombay, and Jamsetji Jejeebhoy, who was specially escorted to the site for the ceremony, all the way from his residence, by the Governor.

In the Reign of Her Most Gracious Majesty
Victoria

And under the Government of Edward, Lord Ellenborough,
Governor-General of India; George, Marquis of
Tweeddale, being Governor of Madras, and the Honourable
Sir George Arthur Bart, K.C.H. Governor of Bombay;
the Foundation stone of the Jamsetjee Jejeebhoy Hospital
was laid with Masonic Honours, in the Presence of
Sir Jamsetjee Jejeebhoy
The founder, And of His Excellency the Governor,
James Burns, K.H.

Provincial Grand Master of Western India; Assisted by the Hon. George W. Anderson; Pro. P.P.G.M.P.W. Le Geyt Esq., D.P.G.M. Lestock R. Reid, Esq., P.G.S.W. Lieut. Col. Neil Campbell, P.G.J.W. Capt. W. Good-fellow, the Architect. And a numerous convocation of the Craft, On Tuesday the third Day of January, In the year of Christian Era 1843, and the Masonry 5843. This Edifice was erected as a testimony Devoted Loyally to the Young Queen of the British Isles, and of unmingled respect for the Just and Paternal British Government in India; also, in affectionate and patriotic solicitude for the welfare of the poor classes of all races among his countrymen, the British subject of Bombay.

by Sir Jamsetjee Jejeebhoy, Knight

The first native of India honoured with British Knighthood who thus hoped to perform a pleasing duty towards his Government, his country, and his people; and in solemn

remembrance of blessings bestowed. To present this, His offering of religious gratitude, to

Almighty God

The Father in Heaven of Christians, the Hindoo, the Mahomedan and the Parsee, with Humble, Earnest Prayer for His Continued Care and Blessing upon his children—his family—His tribe—and his country.¹⁹

The hospital building was completed within two years and formally declared open on 15 May 1845, by Sir George Arthur Bart, in the presence of a large and distinguished audience. The first batch of patients was admitted to hospital on the twenty-eighth of the same month.

Jamsetji Jejeebhoy was the youngest son of Jejeebhoy Vatcha, a weaver of Navsari. Jamsetji was born in Bombay on 15 July 1783 in a modest locality near Crawford market. Orphaned at the age of 15 and almost penniless, he came to Bombay to eke out a living in the city, under the guidance of his uncle, by selling empty bottles. Inspired by the pioneering trip of Hirji Readymoney to China and with his love for adventure, Jamsetji undertook five perilous trips to China, in small sailing ships weighing about a thousand tons each, in order to build up business relations with Chinese merchants. During one of these voyages, he was held captive by the French and deprived of many of his worldly possessions. Despite many vicissitudes, including the death of six of his offspring in infancy, he was able to build up a huge fortune through business ties with distant lands, including China, Egypt and the United Kingdom.

His generosity for the poor and keenness to help the needy was well known. He was responsible for establishing, besides numerous schools and charitable institutions, the first civil hospital of Bombay, the first gynaecological or lying-in hospital of Bombay, numerous wells and waterways in the suburbs and villages of Bombay Presidency, the first great causeway of Bombay, the first waterworks of Poona and the first school of art (J.J. School of Art, established in 1857). Married to a 10-year old girl, Avambai Bottlewalla, at the age of 20 years, Jamsetji, had many firsts to his credit. For his great munificence and generosity of heart, he was amply and rightly honoured during his life-time, being perhaps the most honoured Asian of the early British days in India. He was the first and only Indian Director of the Bombay Bank, the first Honorary President of the Bombay Association, the first Indian Fellow of the newly-established University of Bombay (despite the fact he never attended school in life), the first Asian to receive Knighthood from the British, recipient of a specially made diamond studded gold medal from Queen Victoria 'in honour of his munificence and patriotism', and the first Asian to receive the Freedom of the City of London in

1855, a unique honour bestowed on him 'as a testimonial of the high estimation entertained of him by the Corporation of the City of London and from respect for his justly renowned character as a princely benefactor of his country and mankind, a noble example of blameless commercial integrity, as a most eminent British subject and merchant in India'. On 24 May 1857, Jamsetji attained the peak of his glittering career, when Baronetcy was conferred on him by Queen Victoria in her Birthday Honours List.

On 15 April 1859, the day Jamsetji died the entire Bombay was mourning. All the banks, government offices, schools and shops remained closed and flags flew half-mast all over the city as a mark of respect to a great citizen and friend of the poor.²⁰

OTHER MEDICAL COLLEGES

Carmichael Medical College

Besides the Calcutta Medical College run by the government, other medical institutions run by private organizations also came up in Calcutta. Calcutta Medical School near Calcutta was the first non-official medical institution managed and staffed entirely by Indians. It was started by Indian medical practitioners in 1886 and was connected with the Albert Victor Hospital of 200 beds. In 1903, it was amalgamated with another non-official institution, the College of Physicians and Surgeons of Bengal, which was started in 1897-98. In 1903, the institution was shifted to Belgachia. In 1915, the government promised to make a capital grant of five lakhs of rupees for new buildings, and an annual grant of Rs 50,000 to this combined institution on the conditions that the college would put up the necessary laboratories and the required equipment, and get affiliated to the Calcutta University. These conditions being fulfilled the college was formally opened in 1916 and affiliated to the Calcutta University. It was then named Belgachia Medical College. In 1919, it was renamed Carmichael Medical College after the name of the Governor of Bengal.

The King Edward Medical College, Lahore

In 1837, Sir John Lawrence thought of establishing a medical college in Lahore, but financial difficulties stood in the way and it was not until 1860 that the college was started in the old Artillery Hospital in Anarkali. The first hospital attached to the college was located in the stables of Raja Suchet Singh in the Tibbi Bazar. In 1883, the college moved to the site of the Mayo Hospital. The cost of constructing the College and the Hospital amounted

to more than 40 lakhs of rupees which was met partly by public subscription and partly by government grant. It was named The King Edward College in 1910 in memory of King Edward VII. The Medical School formed part of the College till 1920 when the former was located at Amritsar. The College drew students not only from Punjab, but also from North-West Frontier Provinces, the United Provinces, Rajputana and other parts of India.

The King George's Medical College, Lucknow

To begin with, it was a non-government institution founded at the initiative of Raja Sir Tosadduq Rasul Khan of Jehangirabad, to commemorate the visit to India in 1905 of King Emperor George V (then Prince of Wales). The foundation stone of the college at Lucknow was laid by the future King George V on 26 November 1905. It was located at Shahmina, overlooking the river Gomti, near Lucknow city. The college was formally opened by Sir John Hewett, the Lieutenant-Governor on 25 January 1912. It was named King George's College though at the time of laying its foundation stone, the suggested name was the Prince of Wales College. A magnificent new hospital was also constructed and attached with this college. The estimated cost of the medical college was thirteen lakhs of rupees, and of the hospital twenty lakhs of rupees. The course of study leading to a University degree lasted for five years.

The Prince of Wales Medical College, Patna

It had its origin in the Temple Medical School which was established in 1874. When the province of Bihar and Orissa was created in 1912, the need for a medical college was felt, but as it was not possible to start a medical college at that time, the provincial government arranged with the Government of Bengal to reserve 18 seats in the Calcutta Medical College for the students of this province. In 1920, the Honourable Maharajadhiraj of Darbhanga gave a donation of five lakhs of rupees for the establishment of a medical college, and a sum of Rs 9,25,000 was raised by public subscription. The college started functioning in July 1925. It was named The Prince of Wales Medical College in 1921 to commemorate the visit to India of His Royal Highness, The prince of Wales.

Seth Gordhandas Sunderdas Medical College, Bombay

A non-government institution, it owes its origin to the endowment in 1916 of fourteen and a half lakhs of rupees from Seth Gordhandas Sunderdas Trust. The trustees offered the amount to the Bombay Municipal Corporation for

the foundation of a medical college in association with King Edward VII Memorial Hospital which the Corporation had already undertaken to build, equip and maintain. The endowment was made under certain conditions, the most important of which was that all the professors and teachers to be employed should be properly qualified Indian gentlemen, not in government service. The cost of constructing and equipping the college amounted to Rs 18,96,132 and of the hospital Rs 52,91,915. The college was opened in June 1925. The college was affiliated to the University of Bombay for the M.B.B.S. degree in 1926.

Medical College, Vizagapatam (Madras)

This college was founded by the Government of Madras in 1923 in response to the wishes of the people of the Telugu districts and was affiliated to the University of Madras for the M.B.B.S. degree. The college opened on the 1 July 1923 with departments of Physics, Chemistry, Biology, Anatomy and Physiology, in the building originally constructed for a medical school by Maharani Lady Goday Chittijanakkiammah Gajapathi Rao Garu. The building proved insufficient and extensions became imperative; a block was constructed in close proximity to the King George Hospital for teaching Pathology and Bacteriology and was occupied in July 1925. The departments of physiology, biology and anatomy were housed in a building erected in 1927 near the old college building and those of pharmacology, hygiene and biochemistry in another building completed in 1932.

Lady Hardinge Medical College for Women, New Delhi

It started as a non-government institution although supported almost entirely by the Government of India. It was founded to commemorate the visit to Delhi in 1911 of the Queen Empress. On the initiative of Lady Hardinge, a sum of thirty lakhs of rupees was raised by public subscription to meet the cost of buildings and equipment, and after her death in 1914, it was decided to call it the Lady Hardinge Medical College, in accordance with the wishes of Queen Mary. The college was opened by Lord Hardinge on 17 February 1916. It was meant only for women students and was affiliated to the Punjab University.

MEDICAL SCHOOLS

The three medical colleges at Calcutta, Madras and Bombay, did not have enough capacity to train doctors to fulfil the needs of the country. More doctors were needed for subordinate jobs, and they were supplied by medi-

cal schools opened for the purpose. These schools were located in almost all the larger cities in Bengal, Madras, Bombay, Punjab, United Provinces, etc. The schools taught the students in vernacular languages such as Bengali, Hindustani, Urdu, Tamil, Telugu, Malayalam, etc. and had shorter courses of studies. Later on they also switched on to English medium.

Medical School at Hyderabad

This school was unique because here for long, teaching was imparted in Urdu language, this being the state language in the Nizam's territory.

The teaching method adopted by Dr Maclean, the Superintendent consisted in repeated recapitulation of the lessons, supported by daily examination. The lectures were compiled from standard works in medicine and translated into Urdu. He was assisted in this by Sub-Assistant Surgeon Murray who had a good knowledge of Urdu, and by a *munshi* Meer Ahmed Ali. Dr Maclean added material from his own experience. Each student copied the lectures. The work was difficult and slow and required considerable patience and perseverance on the part of the teacher as well as students, particularly so in the earlier stages. Technical terms, which could not be conveniently translated intelligently into Urdu, were retained and taught in original Latin.^{21,22}

While teaching in Urdu had its advantages, it had many obvious disadvantages too. The Examining Committee in 1952, suggested 'that it is far better for the native pupil to acquire the language of his teacher and by doing so to open up for himself the whole field of Western science with all its concomitant advantages, than for the teacher laboriously to acquire his pupils' tongue and then impart a certain amount of knowledge which from the present experience can scarcely be added to in the present state of Hindustani literature'.

It was, however, not possible to introduce teaching in English medium in Nizam's territory. English language was not at all favoured by the Moham-medan population of Hyderabad. The prejudice against it was such that knowing the language amounted to demeaning oneself in social esteem. Even those who knew English were hesitant of acknowledging their acquaintance with it and very rarely communicated in that language. Under these circumstances, the only channel through which the knowledge of Western medicine could be brought to the pupils was through the local language, Urdu.

The success of Dr Maclean and his small band of assistants was indeed remarkable when judged against the background of the then prevail-

ing social conditions in Hyderabad. George Smith in his account of the Hyderabad Medical College succinctly summarized the situation thus: 'In commencing his labours, Dr Maclean found that the difficulties before him were very considerable. He was single-handed, he had various and difficult subjects to teach, subjects involving great responsibility on the part of both the teacher and the taught; he had to deliver instruction in a foreign tongue, to a people full of prejudice, of inactive habits, and of tastes more military than literary. He had to teach, translate, encourage, conciliate. He had to create a demand for Western medical and surgical skill, where little want was felt or acknowledged. The pupils on their part had but little encouragement; their prospects were somewhat distant and indefinite; moreover, they were exposed to the ridicule of some, and to the opposition of others, whose livelihood might afterwards be affected by their success. Besides this, there were no textbooks; moreover, the preliminary education acquired by the lads was not of a kind to give a teacher any very elevated platform of general knowledge, on which to raise the superstructure of medical science'.

Dr Maclean and his associates in the course of four decades (1850-90) of hard work could translate into Urdu as many as forty textbooks in the different branches of medicine for use in Hyderabad school as well as in other medical schools in India.

In 1883, the medium of instruction in the school was changed to English by the then principal Surgeon-Major Thomas Beaumont.

Before 1872 there was a great difference in the admission rules, teaching curriculum, syllabi, duration of the course, etc. in different medical schools in Bengal and in other parts of the country. In order to bring uniformity in the pattern of admission to medical schools in Bengal Presidency and other places, in 1872 new rules were framed for the selection and training of native medical pupils in these schools.

Gradually, the medium of instruction in all the medical schools was changed from vernacular to English. The standard of teaching was lower than in the colleges, and the curriculum shorter. Successful candidates were awarded a diploma to practise, which became registrable after 1923. These schools themselves regulated the admissions and training in contrast to the medical colleges whose admission and training was regulated by the University to which they were affiliated.

In 1914, there were in India five medical colleges, viz., at Calcutta, Madras, Bombay, Lahore and Lucknow, and 15 medical schools, viz., the Campbell at Calcutta, and the schools at Patna, Cuttack, Rangoon, Lahore, Agra, Dibrugarh, Poona, Hyderabad (Sind), Ahmedabad, Tanjore, Royapuram, Vizagapatnam, and Women's Christian Medical School at

Ludhiana.²³ The total number of students in the five colleges in the year 1916 was 2,311 (Calcutta: male 956, female 24; Bombay: male 589, female 42; Madras: male 386, female 33; Lahore: male 172, female nil; Lucknow: male 104, female nil). The total number of students in all the medical schools was 2,453 (male 2,340, female 113). In 1914, no less than 702 students applied for admission to the Calcutta Medical College and only 154 could be taken. The government bestowed more attention and finances to education in medical colleges rather than in the medical schools.

EVALUATION OF MEDICAL EDUCATION

It is interesting to know what foreign doctors thought of medical education in India. Dr Nicholas Senn, a Chicago Surgeon who came to India in 1903, gave his opinion in this regard as follows. He said:²⁴ 'The number of medical students in the different institutions (four medical colleges at Madras, Calcutta, Lahore and Bombay) at the present time is about 2,000. Very few Mohammedans study medicine; the great majority of students are Hindus and Parsees. The Hindus are said to be the brightest students. The classes have increased in size very rapidly during the last few years, so rapidly indeed that space and equipment in all the schools have become entirely inadequate. From what I have seen of the students in the different medical colleges I have become impressed with their lively, cheerful dispositions and their earnest devotion to their work. The teaching force, as a rule, is inadequate in number in all the schools, and in consequence the men are overworked. I will give only one striking instance of this kind. Lieut.-Col. Dimmock of Bombay is Director of the Jamsetji Jejeebhoy Hospital, Principal of Grant Medical College, and Professor of Obstetrics, Gynaecology and Diseases of Children.'

Evaluating the state of medical education in India, Dr Hehir in 1923, wrote:²⁵ 'It has been stated that professors are changed from one chair to another constantly to the detriment of medical education in India, and I am afraid that this charge is not altogether without foundation; as this is unfortunately still occasionally done, though it is usually for short periods only while the permanent incumbent is on temporary leave. In former years, I was lent to H.E.H. the Nizam's government. I lectured at the Hyderabad Medical School on no fewer than six subjects—histology, pathology, medical jurisprudence, hygiene, theory and practice of medicine and clinical medicine—as a rule doing two of the subjects at the same time each session; but that was a generation ago, and great advance has taken place in medical education in India since then. I am here pleading for the rigid observance of

a principle; it should at this date scarcely be necessary to deprecate the switching off of officers from one professorship to another. One holds firmly that appointments to these professorships should be made solely with the object of giving the highest standard of tuition in the medical colleges and hospitals connected with them that is possible. If this cannot be done in particular cases by the appointment of I.M.S. men then they should be open to the best men that government can afford to secure, whether they be specialists among the members of the independent medical profession in India or anywhere in the British Empire. They should be permanent appointments and the holders should not be liable to transfer except to similar professorships in other medical institutions in the country.'

Dr Hehir was sore that professorships in the medical colleges had been opened up to inadequately trained Indian teachers when sufficiently, trained European I.M.S. Officers were available for the job. He said:²⁶ 'The I.M.S. contains an abundance of highly qualified men for all the professional chairs; these appointments could be filled two or three times over by suitable men of that service. Most of the I.M.S. anatomists and physiologists have filled teaching posts on these subjects or given special study to them either before entering the service or when at home on leave. The same holds good as regards medicine, surgery, pathology, midwifery and public health. Most European I.M.S. Officers put in altogether one and a half to two years during their service in special education in the United Kingdom. This time is employed at post-graduate courses, expert training for specialist appointments or particular lecturerships, and preparation for higher professional examinations. All this has much to do with their eligibility for professorships and higher appointments. There are few opportunities for the ordinary medical practitioner in India to attain to such high standards for teaching purposes—medical education in India has little that lends itself to such higher training after graduation'.

The licentiate diploma awarded by the medical schools in India was not recognised by the Indian Medical Council which was established in 1933. Because of this as well as the fact that the licentiates felt themselves inferior to the graduates of the medical colleges, it was suggested by the Licentiate Association that the system of medical schools be abolished and only graduate courses in medical colleges established and licentiates be given a chance of completing their studies to graduation.

In 1938, the first step towards a uniform standard of medical education was taken by the Government of Madras when they ordered that with effect from that year there should be no fresh admissions to the Stanley Medical School, or to the Medical School for Women in Madras. The Stanley Medical

School (successor of Royapuram Medical School) was actually shortly afterwards, converted into a Medical College, accommodating both men and women students. By 1942, the medical schools at Cuttack, Agra and Amritsar had become colleges, thus completing the conversion in the provinces of Madras, the United Provinces, Orissa and Punjab, while proposals were afoot for the conversion of schools into colleges in other provinces.

MEDICAL EDUCATION FOR WOMEN

Women patients were admitted to the Government and Municipal hospitals since their establishment, but the attendance of women was usually negligible because of the strict *purdah* observed by women in many parts of India and the fact that there were no women doctors on the hospital staff. As a result, the medical care of women was handled by the quack midwives (*dais*) with their primitive and often barbaric practices of treatment.

The first organized work of teaching women in Western medicine was taken up in Madras Presidency. This was initiated by the efforts of Dr Balfour, Surgeon-General, and Mrs Scharlieb, an English woman. Mrs Scharlieb had come to India in 1866 with her husband who was a barrister in Madras. She heard and saw the suffering of Indian women because the services of female doctors were not available and the Indian women were hesitant to be treated by male doctors. Mrs Scharlieb took one year's course in midwifery at the Madras Maternity Hospital. But after having completed it, felt that midwifery training was inadequate to meet all the needs of the women patients in India. She proposed to the then Governor, Lord Hobart, and Dr Balfour, Surgeon-General, that permission be granted to women students to enter Madras Medical College. In 1872, Dr Balfour took up the cause of medical education for women to meet the needs of the women patients of India. The Director of Public Instruction regarded this move as 'entirely premature', and did not recommend admission of women to the Medical College. In 1874, however, Dr Balfour again put in the proposal, and this time he found a strong supporter in Dr Furnell, Principal of the Medical College.

In 1875, four students, including Mrs Scharlieb were admitted. All of them were of European or Anglo-Indian origin. All four students entered what was then called the Certificate Class. This was a short course of three years meant for the students who had not matriculated.

Journal Scorns the Idea

A lot of skepticism was expressed in many quarters about the advisability of training women as doctors. In an editorial, an Indian medical journal,

stated:²⁷ 'While Universities and Corporations in Great Britain are discussing whether women shall be permitted the means of studying medicine and granted the privilege of medical licences and degrees; while the Medical Council is deeply and doubtfully exercised on the subject; while the demand for female medical education is making itself feebly heard in the community and being loudly asserted by a few would-be female medicos and their friends and supporters; while the whole thing is looked on in the light of a very doubtful experiment—doubtful as regards propriety and success—in Madras a scheme of medical education and qualification of women has been hatched when no demand for it existed, and, at the instigation of the head of the medical department, government has authorised special arrangements for the instruction of women at the Madras College, and put the state to considerable expense for that purpose, and even proposed to pay women for being so educated.'

The whole editorial was full of contempt for the scheme of training lady doctors for the purpose of treating women patients. As if the first editorial did not express all what the editor intended to say, in another place, the journal said:²⁸ 'That female doctors are really demanded by the people of India is a pure assumption to start with; that females of any kind are fit to be doctors is a very doubtful point'.

Scharlieb, the First Woman Medical Student

Nonetheless, these four female students started attending the lectures with the male students and did clinical work in the Women's Hospital under Surgeon Branfoot who received them with remarks on the folly and inadvisability of educating women as doctors. Since the government had sent them, he lamented, he could not prevent them walking round the wards, but was firmly determined not to teach them! However, his bark was worse than his bite, and the women made good progress and all passed the final examination at the end of three years. Their Principal remarked: 'They have been remarkable for their assiduity, regularity, keen interest and strongly marked desire to attain proficiency in every branch of the work they have so nobly undertaken'.

Irked by the outstanding performance of the women doctors, the same journal, even in 1882, poured forth its gall against the concept of women doctors. It stated:²⁹ 'Is it feasible? Have native ladies, as society is now constituted, sufficient physical and moral stamina for the work and position? Would they in the present state of native society be admitted into zenanas? Are the middle classes as a rule able to afford a double set of medical

attendants, male for the male, female for the women? How and where are they to be educated? Destined for exclusive practice among their own sex, are they to be taught medicine as men are taught with a view to practise among both sexes, or in a modified manner in special schools and hospitals? The editorial then stated: 'These are difficult questions and can only be answered as yet on more or less *a priori* grounds. We have not touched on the question of the physical, mental and moral fitness of women for studying or practising medicine. We have our own views on this point, but it seems unnecessary to state them in this connection. One thing is undoubted and experience has amply proved it: Women are physically, mentally and morally fitted for the profession of nursing. Much good has already been achieved by systematically educating native women in this line. It is possible that by gradually developing this system of education and training, and imparting to women undergoing training as nurses some theoretical knowledge of medicine and the diseases to which women and children are specially subject, the end in view may eventually be attained by safer and surer means, than by launching at once into a social experiment of doubtful promise.'

At the back of the editor's mind seems to have been the fear that in time the female doctors may come to compete with male doctors. That is why he praised the qualities of the heart of the women and suggested that in his opinion the women would always prove to be worthy of the nursing profession.

Scharlieb's Times

Mrs Scharlieb's *Reminiscences* throw interesting side-lights on the hospitals, doctors, and the life in Madras in the second quarter of the nineteenth century.

Writing about how she and her colleagues were received in the lying-in hospital where they were to get their training in midwifery, she said:³⁰

I explained my views and desires as to the medical education of women to Dr Balfour. He most kindly offered to take me to the lying-in hospital, and to commend me to the practical teaching of its superintendent, Surgeon-Major Cockerill who was a tall, thin man, with Dundreary whiskers, and a general air of finding the climate and work too much for him. He listened to the Surgeon-General and to me, but was not in the least convinced that my prayer should be granted. He told me that I did not know what I was asking for, that the work was not suitable for an English lady, that it involved much unpleasantness and dirt, and that it was such as he would not permit his wife to undertake. I replied that whether I should like it or not, was for me to judge, that my

clothes would wash, and that soap and water plus carbolic acid would secure the cleanliness. His next objection was that my husband could not possibly approve of my training as a midwife, to which I replied that if he had not approved, I could not have been there. Finally, he asked whether if he accepted me as a pupil, I would be ready to attend any case assigned to me, and to keep the rules of the institution. To this of course I gladly assented.

Then he invited me to accompany him to a thatched shed in the hospital compound. At the other end of this shed, lay a woman quite unconscious, and swollen beyond all recognition. I did not know what was the matter with her, and in my ignorance thought it might be a very terrible case of leprosy, but Dr Cockerill asked me whether I would attend her, and when, I, of course, said that I was willing to do so, he explained that it was the worst case of confluent smallpox he had ever seen, and asked whether I would attend her in the face of that assertion. What could I do but still consent.

Describing the lying-in hospital and the training she had there, Mrs Scharlieb said:

The old lying-in hospital in Madras was a low rambling, a part of which was reserved for European and East Indian women, but much the larger part of which was for the service of low caste women and such Mahommedans as did not object to being attended by men. The Superintendent, Dr Cockerill, visited it every morning from 6.30 to 9.30 a.m. He went round the wards, saw the gynaecological patients, visited the various sheds in which were special cases, and occasionally lectured to midwifery students. Under him were two 'Apothecaries', officers whose duties corresponded with those of house-surgeons or obstetric assistants at an English hospital. They both went round with the Superintendent in the morning, and each had stated hours of duty during the day and night. I soon came to the conclusion that the most important person with whom I should have to do was Mrs Secluna, the matron. In spite of her Spanish name she was English by birth, a big fair woman who had fifteen children herself and was one of the most skilful midwives and most kindly people that I ever had the good luck to meet. She, at any rate, approved of my desire to learn practical midwifery; she kept me by her all the day, made me share in the instructions she gave to her nurses and pupils, and supervised my first attempts at acquiring the art as well as the science of obstetrics.³¹

Writing about the facilities the women students received, Mrs Scharlieb stated:

The arrangements for the medical education of women students were conceived in a generous spirit. We were to pay no fees, our textbooks were given to us, and a comfortable room at the Medical College was assigned to our use. So far as lectures went, we shared in the instruction given to the large body of young men who were

attested students to be Assistant Surgeons and Sub-Assistant Surgeons in military and civil employ under government. Practical midwifery we were to learn at the lying-in hospital, and other clinical work was to be done by us at the Women's Hospital under the medical superintendent of Surgeon A.M. Branfoot whereas the young men took their clinical surgery and medicine at the great General Hospital at Madras, which was close to the Medical College.

She went on to say:

My three women colleagues remained at the Women's Hospital and I went alone to share in the clinical work with my male fellow students. I ought to say at once that none of us ever met with slightest discourtesy or difficulty either at college or hospital; and that when our curriculum was finished and we had obtained the diploma of the college, the Principal, Dr M.C. Furnell, told me that the coming of the women had been a great advantage to the men, for our companionship had sweetened their manners, and our eagerness to learn had been a useful stimulus.³²

After Mrs Scharlieb had completed her studies, in 1885 she was offered the job of a lecturer. About this, she wrote:

I had a letter one day about eleven o'clock from the Superintendent-General of the College, asking me whether I would accept appointment to the lecturership on Midwifery, Gynaecology and Diseases of Children to the women students, and if so, when could I take up my duties. This should, he said, be done with the least delay possible, as the winter session was then beginning; the hour of lecture was from twelve to one daily. I wrote a note signifying my acceptance of the honour, and saying that I would be at the college at twelve o'clock. I went to the college, was very kindly received by the principal and lectured to the women on the anatomy of the female pelvis. This appointment as lecturer was very gratifying to me. I loved teaching, and I was glad to be of some service to the young women students. Shortly after my appointment as lecturer to the Medical College, I was honoured by being appointed examiner in Obstetrics and Gynaecology in the University of Madras.³³

Between 1878-82, Mrs Scharlieb had gone to England for further studies. Before returning to Madras, she had an interview with Queen Victoria, to whom she gave a plain account of the sufferings of Indian women during illness, and the cruelty inflicted on them by the native midwives. The Queen, who had heard something already from Dr Bielby, turned to Lady Biddulph and said: 'How can they tell me there is no need for medical women in India?' The Queen sent a kind message to the women of India, and gave Mrs Scharlieb her photograph that she might take it to the houses of the people to show them how much Queen felt for them. Mrs Scharlieb was also sent for by the Prince and Princess of Wales (afterwards King Edward VII and

Queen Alexandria), who listened with the greatest interest and sympathy to her account for the suffering of the Indian women.

Mrs Scharlieb, on her return to India, started her medical practice in Madras, and soon had more patients than she could manage. She perceived that her work could never be wholly successful until she had a hospital. She sought the help of the Governor's wife, Lady Grant Duff, and of the Surgeon-General, and a meeting with the leading members of the Indian community was held. Funds were collected and it was decided to have a hospital for higher caste women to be in charge of Mrs Scharlieb. A beginning was made in a hired house. The hospital was a success from the beginning and the work was very strenuous. The committee agreed to the appointment of a second medical woman, Miss Pailthorpe, as assistant to Mrs Scharlieb. In 1887, Mrs Scharlieb's health gave way, and she was obliged under medical advice to leave India for good.

Clara Swain M.D. Arrives from the U.S.A.

The first woman already qualified in Western medicine to come to India was Dr (Miss) Clara Swain, M.D., from the United States of America. On seeing the need and suffering of Indian women, some Christian missionaries had earlier tried to impart medical education to Indian women on their own as a private arrangement. Dr Humphrey, a member of the Methodist Episcopal Church, actually started a class for training women at Nainital in 1869. The venture did not succeed and the class was closed in 1872. The same Mission, however, wrote to America requesting for the service of a medical woman to instruct a class of native Christian girls, as also to practise in the city as opportunity presented. The one who responded to this call was Dr Clara Swain. She started from New York in November 1869, and arrived at Bareilly in the United Provinces on January 2, 1870. Dr Swain at once took up the work of teaching medicine, nursing and compounding, to a class of fourteen girls of the orphanage attached to the mission at Bareilly.

For teaching the students as well as for treating the patients, Dr Swain felt the need of having a regular hospital and dispensary. This was made possible when the Nawab of Rampur gifted a piece of land for it. The cost of the two buildings, including a residence for the doctor, was about Rs 35,000. The dispensary was opened in 1873 and the hospital in 1874. Dr Swain remained in charge of it till 1885 when she was asked by the Raja of Khetri to take up the post of physician to his Rani and her ladies. This she did on the understanding that she was allowed to carry on missionary work.

Missionary Women Doctors

Among the other Christian missionary women doctors were Miss Sara C. Seward, M.D., who came to India in 1871 and started work at Allahabad; Miss Rose Greenfield came to Ludhiana in the Punjab in 1875; Miss Fanny Butler, M.D., who came in 1880 and set to work at Jabalpur and later went to Bhagalpur and Kashmir; Miss Elizabeth Bielby who arrived in Lucknow in 1876, went back to England to qualify as a doctor and came back to Lahore and took charge of a newly established women's hospital set up in 1888; Maria White who came to India in 1875 and settled to work in Sailkot; Miss Ida Faye who came in 1881 to Nellore; Dr Jessie Carleton who came to Ambala city in 1887 and succeeded in setting up in 1901 the Philadelphia Hospital for women, and Dr Alice Ernest who came to Jhansi in 1887.

The work of foreign missionary women doctors in different parts of India among women patients helped Indian women to avail of their services, and also made it easy for Indian women doctors to qualify in medicine and to set up private practice, or to get attached to women and children hospitals which started coming up gradually in different parts of the country.³⁴

In the Bombay Presidency, there was no opposition to women medical education. In 1887, 17 women were studying at the Grant Medical College of whom two were matriculates working for the L.M. and S. Degree, while the others were studying for 'Certified Practitioners' course. They were Europeans, Anglo-Indians, Portuguese, Parsees and Hindus. Separate classes were not considered necessary.

In the year 1883, the Medical Faculty of the Punjab University discussed the question of educating native women in medicine and surgery, and suggested that the best means would be to form a class in the Medical College, Lahore. Surgeon-General Townsend addressed the Punjab Government on the subject and received a favourable reply. Six scholarships of Rs 10 p.m. were granted. In 1885, there were ten students, seven of whom were in their second year of study. These students were required to know Urdu, Hindi or English and were examined in the language of their choice. Scholarships were also given by the district administration in the Punjab, on the understanding that the students returned to work in the same district. At the same time two students were admitted into the Assistant Surgeon class studying for the University degree, after having passed the entrance examination of the Punjab University. They were both Anglo-Indians.

In 1886, the Lahore Municipality proposed to secure the services of a properly trained doctor from England for the benefit of the women of the city. The lady selected was Miss Bielby, who previously had experience of medi-

cal work among women in Lucknow. Later on the Lady Aitchison Hospital was started in Lahore and the women students were educated in the same way as at Agra till 1916, when the government closed this school and transferred its grants to the mission school at Ludhiana.

In order to have an institution totally meant for the purpose of teaching women doctors, a lady missionary, Dr Edith Brown, with the help of two other missionaries, Miss Greenfield and Miss Hewlett, started a medical school for women in Ludhiana, Punjab. Different Christian missionary societies working in India financially supported the project. At first the school granted its own diplomas, but later the students from the school were admitted to the examinations held for the Sub-Assistant class in Lahore. The school made steady progress. In 1916 the Punjab Government decided to close the classes for women in Lahore and gave more attention to the Provincial Medical School, Ludhiana. Gradually more and more non-Christian medical students were admitted to this school. The Punjab Government contributed largely to the buildings of the school and about half the running expenses were also provided by it. For many years the school at Ludhiana was the only one in India where girls were taught entirely by members of their own sex. Many of the girls from as far away as Madras came here for training.

As the number of medical students from South India seeking admission to Ludhiana became larger, the missionary bodies there began to feel that a medical school on the lines of the school at Ludhiana was necessary for the South. The school was opened in 1918 in Vellore, mainly owing to the fact that a very fine medical and surgical infrastructure was in existence there under the leadership of Dr Ida Scudder, a member of the Dutch Reformed Church of America. The students at Vellore appeared for the L.M.P. certificate of Madras which was equivalent to the Sub-Assistant Surgeon course.

The schools at Ludhiana and Vellore were Christian Mission School and the certificates or degrees they awarded were lower than graduation. So at the beginning of the second decade of the present century a proposal was afoot to have a Medical College exclusively for women. On the occasion of the visit of Queen Mary to India for the Coronation ceremony in 1911, the Maharaja of Kotah along with other ruling princes, gave generous donations for the establishment of such a college. Lady Hardinge, wife of the then Viceroy, and Sir Pardey Lukis, the Director-General of Indian Medical Service, supported it. It was decided to have the college at Delhi which had recently become the capital of the country. The foundation stone of the building was laid in 1913, and the college was opened in 1916 by Lord Hardinge. The original proposal was to name the college after the Queen-

Empress, but because of the untimely death of Lady Hardinge who had done so much for the opening of the College, Her Majesty felt it was befitting to name it after Lady Hardinge. The college was affiliated to Punjab University for the M.B.B.S. Degree. The students after qualifying became assistants at Dufferin or other hospitals, or started private practice.

The question of admitting women to the Calcutta Medical College was raised as early as 1876, again in 1879, and then in 1882. The Council of the Medical College was hesitant, but the Secretary to the Government and finally the Lieutenant-Governor himself took the initiative to arrange admission of women candidates. Mr Rivers Thompson, the then Lieutenant-Governor, over-ruled the decision of the College Council and 'considered it a matter for great regret that Bengali ladies fully qualified by education had to go to Madras for training'.

Women were admitted in the Calcutta Medical College for the first time in 1885. Two factors helped to secure this: one, the Maharani of Kasimbazaar gave a donation of Rs 1,50,000 for the construction of a hostel for the female students; two, Sir Walter de Souza promised a sum of Rs 200 p.m. for the benefit of women students. The students were admitted, as in Madras in the certificate class. There was a suggestion that lectures should be duplicated and that the women students should be screened from the men but this was rejected, the women themselves not desiring any such arrangement.

By the year 1890, there were women medical students in Madras, Calcutta, Bombay, Agra and Lahore. The great bulk of the teaching was carried on by men doctors though women doctors also helped. Generally speaking, the women students at Agra and Lahore were poorer in accomplishment than in other places.

Indian Women Pioneers in Medical Education

Among the Indian women pioneers in medical education were Anandibai Joshi, Annie Jagannathan, and Rukhmabai. Anandibai Joshi married at nine, became a mother at thirteen. Her child died and she determined to devote her life to the welfare of her country women. In 1883, she went to America to study medicine. She graduated in 1886 from the Women's Medical College, Pennsylvania, and returned to India as in charge of the women's wards of the Albert Edward Hospital at Kolhapur. Unfortunately, she died of tuberculosis in 1887. Miss Annie Jagannathan was another Indian woman who began her studies in Madras in the year 1883. In 1888 she went to Edinburgh and joined the Edinburgh School of Medicine for Women, recently

opened. She obtained the tripos of the Scottish College in 1892 and came to India to take up the post of House Surgeon to the Cama Hospital. Unfortunately she also died early of tuberculosis in 1894. Rukhmabai was another Indian woman who went to England in 1889 to study at the London School of Medicine for Women. She returned to India in 1895 where she took the charge of the Women's Hospital at Surat. In 1918 she was selected for the Women's Medical Service, but at the same time received the offer of appointment as Medical Officer, in charge of the Zenana State Hospital, Rajkot, which she accepted.

Countess of Dufferin's Fund

All work done till 1885 in connection with the teaching of women doctors and of providing medical facilities to women patients could be considered only as a beginning, because in that year a bigger and bolder scheme was started. This scheme was the formation of the Countess of Dufferin's Fund. Lady Dufferin's proposal to start a fund, to encourage and finance women doctors to open women's hospitals and wards and to train women doctors met with approval. Subscription and donations poured in from Indians and Europeans alike not only to the Central Fund presided over by Lady Dufferin, but to the Provincial Funds opened in each province by the wives of the Governors and Lieutenant-Governors.

The Countess of Dufferin's Fund owed its origin to Queen Victoria who had already been informed of the neglect of women's health in India. When Lady Dufferin came to India in 1883, the Queen-Empress asked her to see what could be done to remedy the situation. From then Lady Dufferin took great pains to acquaint herself with all matters relating to the medical relief of women in India. In 1885 she wrote to the wives of the various Governors and Lieutenant-Governors and being assured of their full support, a prospectus was drawn up and published in various languages all over India. It received warmest possible public response. The Countess of Dufferin's Fund or the National Association for Supplying Female Medical Aid to the women of India was organised in 1885. The Queen-Empress was the Patron, the Viceroy was the Patron in India, the Vicerine was the President, the Governors and Lieutenant-Governors of Provinces were the Vice-Presidents. There were in addition, Life Councillors, Life Members, and Ordinary Members depending upon the amount of donations given. The Association was managed by a Central Committee meeting at Calcutta and Simla of which the Viceroy's wife was President. Each province had its own branch similarly organised which undertook to achieve the aims and objects of the associa-

tion and which were responsible for collecting its own funds. The object of the association was to provide medical relief to women by women and medical tuition of women.

At the end of three years, when Lady Dufferin left India, the Central Committee had collected about seven lakhs rupees. Some large building grants were given to the more important Dufferin Hospitals at Agra and Lahore. Grants-in-aid for the salaries of lady doctors and nurses and scholarships to women students and probationer nurses were given annually.

Indian women came into the medical profession with hesitancy and slowly, but by the second decade of the twentieth century, there were many more applicants than could be accommodated. Women students fared well and after qualifying they were in great demand in women's hospitals opened by a large number of municipalities. They did extremely well in private practice.

At the outbreak of the First World War in 1914, Dr Annette Benson, then President of the Association of Medical Women in India offered the services of its members to the Viceroy, but received a polite refusal. She was thanked for her offer but was told that war duties were not suited for feminine hands. But early in 1917, strict orders were received from the War Office that the services of medical women in India were to be utilised in every possible way. The military authorities consulted the Joint Secretary of the Dufferin Fund as to how the services of medical women could be obtained. On his advice the arrangements were made through a committee, which had been set up for the purpose, to engage medical women as civilian practitioners, and during the remainder of the War, two units were kept in reserve, one in Bombay, the other in Secunderabad.

In 1913, there were 81 women students in medical colleges in India. In 1927, there were 183 hospitals in India with medical women on their staff. Gradually, more and more women students joined medical schools and colleges in the seats reserved for them. The number of qualified lady doctors increased gradually and steadily.

BHORE COMMITTEE REPORT (1946)

The Bhore Committee (1946) dealing with Medical Education, stated:³⁵

Having given serious consideration to the suggestion that, in the conditions now prevailing in the country, it might be desirable to provide both fully trained doctors and a less elaborate type of medical men, the conclusion which the majority of us arrived at is that having regard to the limited resources available for the training of

doctors, it would be to the greater ultimate benefit of the country if these resources were concentrated on the production of only one and that the highly trained, type of physician whom we have termed the 'basic' doctor.

Among other recommendations of the Bhore Committee relating to changes suggested in the undergraduate curriculum were included the following: (1) A reduction in the number of didactic lectures in certain subjects and an emphasis on the inclusion of principles and methods which will enable the student to learn for himself, think, observe and draw conclusions; (2) The establishment in every medical college of a department of Preventive and Social Medicine so as to give the student an insight into social health problems by contacts with home and community life; (3) The inclusion of a year of internship after the qualifying examination, of which three months will be devoted to work in a public health unit and the remaining period in a hospital of approved standard; (4) The importance of research should be stressed and the whole-time teachers should engage themselves in research and encourage any student showing aptitude or learning to participate in research.

About post-graduate medical education, the committee recommended that the same should be given to meet two different needs: (1) the training of consultants and specialists, and (2) the training of practitioners desirous of practising a speciality without the definite status of a specialist. In the case of the first category, it was recommended that such training would naturally involve several years of work in special departments and hospitals, leading to a higher qualification, such as the M.D. or M.S. In the case of the second category, the training in the speciality may range from 12 to 18 months depending upon the particular speciality and under some suitable guidance.

One of the main recommendations of the Bhore Committee was the establishment of a special organisation, the Central Committee for Post-graduate Medical Education, to be responsible for laying down standards in respect of post-graduate facilities for such subjects and for promoting the development of facilities basis.

It was stated by the Committee that the main factor which impeded the expansion of medical education was the great shortage of teaching staff. The solution offered for meeting the shortage was: (1) training of medical teachers at the All-India Institute of Medical Sciences, which was expected to supply a 'steady stream of teaching personnel of the highest quality', (2) inviting experienced teachers from foreign countries on a short-term basis, (3) training abroad of least 200 selected members of the medical profes-

sion from the various provinces of India for periods ranging from 2 months to 2 years to acquire knowledge of the improved methods of teaching, particularly in anatomy, physiology, biochemistry, pathology, bacteriology and pharmacology, (4) encouraging younger men of the profession in increasing numbers to acquire post-graduate qualification in this country and later rounding off their education by visits abroad for periods ranging from 6 months to one year.

To preserve a uniform standard of medical education it was urged that the only body for the grant of medical qualification be the universities.

The other important recommendations related to the conversion of medical schools into colleges, improvement of certain existing colleges, and establishment of new colleges.

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Causality, Cardinality and Conditioned Reality

RAJA RAMANNA

Early Buddhist philosophy has much in common with scientific philosophy, a fact referred to by Bertrand Russell and many other students of philosophy. A more detailed work on the logic of the Buddhists is by Stcherbatsky (1984). It consists of two volumes entitled 'Buddhist Logic'. The first volume is devoted to the commentary on Buddhist logic and the other gives the original works translated from the Sanskrit dating up to the sixth century AD.

From these works, one can get an idea of the standpoint of early Buddhism and the meaning of the words 'Conditioned Reality', 'Nothingness' (*Sunyata*), the creative void out of which everything comes into existence, and *Kshana* (instant) and all these have a relevance to modern physics though it is not very well known in Western countries.

Early Buddhism does not depend on a God or the existence of a Soul. The whole universe depends only on the laws of Causality, be it in the material world or the moral sphere. We now know that the former is controlled by the laws of physics and according to early Buddhism, the latter is controlled by a well-regulated life, also determined by causal laws and defined by the Buddha himself in what is known as the *Eight-fold Path*. Since no God is postulated, something else is required to take its place. Thus causality and causal relations become matters of prime importance.

It is the purpose of this paper not only to show the relevance of these older works, but to demonstrate how they can unify much of the foundations of physics and even give quantitative results which are in full agreement with Quantum Mechanics as we know it. In this way, Buddhist logic may throw some light on the problems confronting the foundations of Quantum Mechanics.

By 'Conditioned Reality', we mean that all our Thoughts, Actions and Observations (TAO for short), depend on something or everything else and there is nothing which has an independent existence. It is, however, possible that certain events can take place due to the operation of certain causes whose relation to other causes may not matter, but in general, all recognisable TAOs are conditioned by a very large number—if not an infinite number of other factors. Later, we make use of these concepts to derive values of physical quantities.

The concept of 'Nothingness' is profound and is due to Nagarjuna, the logician of the second century AD. Many books have been written about him and it is remarkable how close his writings come to recent publications in physics, especially the book entitled *Something called nothing—Physical Vacuum, What is it?* by Podolny (1986).

This book points out that the vacuum state is the fundamental one for the beginning of all physical activities by the formation of virtual states. Nagarjuna, from a purely logical exposition, points out that this can be the only possible picture of creative and physical processes. We make no further reference to the theory of Nothingness as it is required only marginally in these considerations. Besides, sufficient literature already exists on the works of Nagarjuna by Zukar (1979), Weber (1986), and Ramanna (1992).

The theory of *Kshana* is a statement of the concept of 'Instants' over whose average values, causes and effects can be quantified. Since this is a commonly accepted notion of time averages, it is not proposed to discuss it in detail but their full implications are given in Stcherbatsky's great work already referred to.

CONDITIONED REALITY

Let $A_1, A_2 \dots A_n \dots$, be the various TAOs and $a_{11}, a_{12}, a_{13} \dots$, etc. be the various *conditions* which generate the TAOs, e.g. A_1 takes place when conditions $a_{11}, a_{12}, a_{13} \dots a_{1n}$ exist. We write all possibilities in matrix form as follows:

Thoughts, Actions & Sequence of Conditions
Observations (TAO)

A_1	a_{11}	a_{12}	a_{13}	—	a_{1n}	—	
A_2	a_{21}	a_{22}	a_{23}	—	a_{2n}	—	
—	—	—	—	—	—	—	... (1)
—	—	—	—	—	—	—	
A_n	a_{n1}	a_{n2}	a_{n3}	—	a_{nn}	—	etc.

The values of the a 's can be 1 or 0 depending on whether the condition is relevant to that particular TAO.

In order to convert the above matrix to represent actual physical quantities and be able to interpret them as physical laws, we invoke the Cantor Diagonal construction which Cantor used in showing the difference between the various types of infinities, particularly between countable and non-countable infinity. The theory in itself is a mathematical differentiation between continuous and discrete quantities. It can also be made the starting point for the foundations of Quantum Mechanics since it deals with physical quantities, which under certain conditions are discrete and in others continuous.

It will be recalled that Cantor proved that if we measure all the points on a continuous line, there are not enough integers to count them all. The method can further be used to prove the celebrated Godel Theorem on Incompleteness.

The Cantor diagonal method consists of writing all the points on a line lying say between 0 and 1 (or in any continuous interval) in decimal notation. Let $S_0 S_1 \dots S_n \dots$ be points on a straight line. We can presume that we can continuously count all the points by taking the decimals to an infinite number.

$$S_0 = 0.X_{00} X_{01} X_{02} X_{03} \dots X_{0n} \dots$$

$$S_1 = 0.X_{10} X_{11} X_{12} X_{13} \dots X_{1n} \dots$$

$$S_2 = 0.X_{20} X_{21} X_{22} X_{23} \dots X_{2n} \dots$$

$$\dots \dots \dots$$

$$\dots \dots \dots$$

$$S_n = 0.X_{n0} X_{n1} X_{n2} X_{n3} \dots X_{nn} \dots$$

$$\dots \dots \dots$$

$$\dots \dots \dots$$

It will, however, be noticed that a number, say S , will not be found in the enumeration if S is created such that

$$S_n \neq 0.X_{00} X_{11} X_{22} X_{33} \dots X_{nn} \dots$$

This is because the particular diagonal element will always be different by definition. This demonstrates that if one tries to enumerate all the points continuously, there are an infinite number of missing entries showing that a countable ∞ is different from a non-countable ∞ .

This method can be used to determine the missing TAO from matrix (1) for each diagonal. There will be in principle $n!$ missing sequences. If for some reason, the events are all ordered, there will be only one such sequence.

After having shown the existence of two kinds of infinities, Cantor went on to show that an infinite number of infinities can be formed by what is known as the Cantor Continuum. The method consists of showing that from a set of positive integers, it is possible to construct another set of integers with a different cardinal number, Courant & Robbin (1978). If a set A consists of three integers $\{1, 2, 3\}$, a set B can be constructed $\{1, 2, 3\}, \{1, 2\}, \{1, 3\}, \{2, 3\}, \{1\}, \{2\}, \{3\}$ and 0 i.e. with 8 different elements. As shown later, this continuum property can be used to get the levels of atoms if a proper correspondence is made. Cantor has in general shown that a set with elements, can generate another set with 2^n elements of a different cardinal number.

Further, if we interchange the rows, there will be a different ordering of the conditional sequences and for each of these sets of sequences there will be a different sequence of the non-diagonal elements, not found among the rows.

From these very general considerations, we proceed to consider the special case where the matrix elements are physical entities. In such a system, we can replace TAO by the word EVENTS.

We consider the following three cases where:

1. the number of conditions and the EVENTS are finite and for every EVENT there is the same number of conditions, i.e. we consider only square matrices;
2. the ordering of the sequences could change depending on the nature of REALITY. This could come about as a result of SPACE-TIME. It may also happen that the number of sequence conditions and the number of EVENTS though finite, may not necessarily be equal. This could happen if the number of EVENTS generated by a sequence of condi-

tions is more than one, OR a number of sequences generate the same EVENT; and

3. the number of EVENTS and associated conditions are both non-countably infinite (continuous). This could happen if the values of the *a*'s are not only restricted to 1 and 0, but could have values continuously between 0 and 1.

As an example of how the matrix (1) can be interpreted, we consider the case where there exists a sequence consisting of only 1's. If the various other sequences are also arranged in such a manner that all the diagonal elements are 1's, the missing sequence will be only 0's. This means that there is no EVENT when there are no conditions. Similarly, if the missing sequence is all 1's, it means that there is no EVENT which require all the conditions to exist. Such cases do not present themselves in actual situations.

Newtonian Physics

Newtonian Physics depends on equations of motion and initial boundary conditions, from which all information about a system can be obtained. We can, therefore, assume that in a classical system, there is a point to point correspondence between a finite number of CAUSES and EVENTS.

Further, in Newtonian Physics there is an absolute coordinate system to which all things can be referred to and velocities of infinite magnitude are permitted. CAUSALITY means that an event cannot take place before the cause. The event, however, can be observed at different points separated from each other at great distances, instantaneously, e.g. NEWTONIAN GRAVITATION.

In Newtonian Physics, time is an irreversible parameter absolutely separated from space. If EVENTS follow a certain time sequence, then the various entries of sequences in the matrix will follow a certain order, as a result of which only one sequence will be missing due to the diagonal effect. One could, in principle, attribute it to time irreversibility.

In physical problems where time dependence is involved, the ordering of the sequence of matrix elements is as important as ordering of the sequences that defines CAUSALITY. Since CAUSALITY implies that under no circumstances EVENT should precede the CAUSE, it reduces the number of possibilities of the various diagonal sequences to one.

Relativistic Physics

In classical physics, space and time are separate entities, but the basis of the Buddhist approach is to recognize the dependence of one on the other.

If, therefore, Space-Time is taken as an integrated 4-dimensional entity, it will be seen that CASE 2 will seem closer to the truth.

CASE 2 is essentially a special case of CASE 1 except that in CASE 2, there is no absolute reference system of co-ordinates and physical laws are invariant in Space-Time. The very assumption of Space-Time implies the existence of a universal finite limiting velocity which in the Theory of Relativity is that of light.

In such systems, there are many EVENTS which satisfy CAUSALITY but do not necessarily have a time sequence. Besides, there could be many EVENTS arising from only one sequence of a conditions OR vice versa there may be many sequences which lead to the same EVENT. This is in agreement with the Theory of Relativity where though CAUSALITY is not disturbed, EVENTS which are neither the cause nor the result of one another, have no time order and a reversal of time order is also possible, Reichenbach (1969). This is possible if the EVENTS are in different light cones.

In our matrix terminology, it means that because of Space-Time, the sequence order can be changed and the same set of conditions can produce different EVENTS.

Quantum Physics

In QUANTUM MECHANICS, we have a very different kind of theory. EVENTS are described by abstract wave functions whose interpretation depends on probability considerations.

The Uncertainty Principle further adds to complexity of defining the CONDITIONS for an EVENT. Even this is not established until a measurement is made and digested by the OBSERVER with a consciousness. Quantum Mechanics predicts the existence of not only observable states which can be measured, but predicts the existence of VIRTUAL states in VACUUM, i.e. in NOTHINGNESS.

In this present matrix formulation, because of the existence of quantised parameters, wave particle duality and of virtual states, the matrix elements could have the following possibilities:

- (a) The matrix elements could have values continuously between 0 and 1. This could come about due to averaging effect over time or as a result of the influence of other parameters;
- (b) The Cantor diagonal construction can also be applied to the other diagonal perpendicular to it and the same considerations can refer to ROWS. Here each ROW refers to a specific CONDITION which requires to be satisfied for a certain set of EVENTS;

- (c) In general, the differential equation provides causal relations in Classical and Quantum Mechanics. In Quantum Mechanics, the solution of the Schroedinger equation depends on the type of boundary conditions one imposes on it. Some quantities get quantised while others remain in a continuum. For example, for a particle in a box, energy is quantised while position remains in a continuum. Thus their cardinality is different. We have from Cantor's Theory of the continuum that n entries from a lower Cardinality will have for the next higher Cardinality 2^n entries.

Possibility (a) which suggests that matrix element values can be between 0 and 1, implies that the matrix elements are changing in time in a random manner (*Kshana* theory). We will not specify how this happens but note that these values come about as some time average. The very fact the values of the matrix elements are continuous implies that it is a non-countable set. It also implies that there are an infinite number of missing values between 0 and 1 which can be determined from the diagonal construction of Cantor. Since the values between 0 and 1 are continuous, there will be an infinite set of possibilities for even a single matrix element and the number of possible diagonals will be infinite. All this can happen for other matrix elements which can have any value between 0 and 1.

We note that (b) implies that many EVENTS require some specific condition to be satisfied before such EVENTS can occur. Some of these conditions would require to be quantised, i.e. they are discrete and others continuous with each matrix element having many possible values.

Cardinality is used essentially to differentiate between discrete and continuous. We consider an actual example from atomic spectroscopy to apply the Continuum Theory to Quantum Mechanics.

It is known that there is a certain natural width ΔE_0 corresponding to an intensity distribution of a spectral line emitted by an atom. In classical theory, this is due to the reaction force of the emitted radiation on the emitting source. In Quantum Mechanics, following the perturbation theoretic treatment due to Weisskopf and Wigner (Heitler [1944]), one gets a formula for ΔE_0 which is consistent with the time-energy uncertainty relation where ΔE_0 is interpreted as an estimate of the accuracy with which an energy level is known, as Δt is the lifetime of the excited state of the atom. The continuum of the line width thus co-exists with the discrete structure of the levels. At higher energies, the levels will begin to overlap and a CONTINUUM of non-enumerable infinite number of states will come into existence.

Let us assume that the ratio of the energy width in the Continuum state,

which is riding on the discrete structure and the Energy of the level, be proportionate to the ratio of the number of discrete states (n) and the next Cardinal number given by 2^n .

$$\text{i.e. } \rho \frac{n}{2^n} = \frac{\Delta E_n}{E} \quad \dots (1)$$

where ρ is some constant of conversion from Cardinal States to Energy states and $\Delta E_0 \approx h/\Delta t$ is the spread of the level of Energy E and is related to the time an atom can retain excess energy before re-emitting it in the form of photons.

We now apply the above formula to the case of a free electron falling to the various levels of the Hydrogen Atom. Table 1 gives the CARDINAL LEVELS, the simplest series of the levels of the Hydrogen Atom and the Energy widths.

Table 1

Cardinality and the width of special lines of Hydrogen for constant ρ

1 <i>Card no.</i>	2 <i>Quantum no.</i>	3 2^n	4 $n/2^n$	5 E (ergs) <i>Energy level</i>	6 ΔE_0 <i>Width (ergs)</i>
1	8	2	0.500	3.37×10^{-13}	1.7×10^{-18}
2	7	4	0.500	4.39	2.2
3	6	8	0.375	5.99	2.2
4	5	16	0.250	8.61	2.2
5	4	32	0.156	13.45	2.1
6	3	64	0.094	24.00	2.25
7	2	128	0.055	53.90	2
8	1	256	0.031	214.00	6

The ratio of the values of $n/2^n$ and $\Delta E_0/E$ is nearly the same provided we allow for the variation of the value of ΔE_0 . ρ some constant which has to have the value of 10^6 .

It will be noticed that the three levels which are nearer the ground state could belong to a separate family having a different cardinality. These first three levels could be of Cardinality 3 which in turn can give rise to 8 levels of higher Cardinality.

From equation (1) it was shown that the natural width of the spectral lines of the Hydrogen Spectrum could be obtained using the Continuum Theory of Cantor. Here we show that the level spacing given by the theory is consistent with the Quantum Theory of the Hydrogen Atom.

Let D_1 be the level spacing of the Hydrogen Atom as given by the Bohr formula.

$$D_1 = \text{Const} \left[\frac{1}{p^2} - \frac{1}{q^2} \right] \dots (2)$$

where p and q are the quantum numbers and the constant is the Rydberg constant. From equation (1) we have D_2 i.e.

$$D_2 = \rho \left(\frac{n}{2^n} - \frac{m}{2^m} \right) = \Delta E_0 \left(\frac{E_n - E_m}{E_m E_n} \right) \dots (3)$$

Table 2 gives the values of D_1 and D_2 . Here the cardinal number 9 corresponds to the quantum number $q = 1$, and the ordering of the cardinal numbers is in reverse order to the quantum numbers. The last column gives ρ/E_0 .

Table 2

Cardinality and the Bohr Theory of the Hydrogen Atom

1	2	3	4	5	6	7	8	
n	$n-1-\left(\frac{n}{2^n}-\frac{n-1}{2^{n-1}}\right) \times 2^8$ $\left(=\frac{D_2}{\rho}\right)$	$\frac{E_n E_{n-1}}{\times 10^{26}}$	$(3)X(4)$ $\times 10^{26} \times 2^8$	p	q	$D_1=R_H h c\left(\frac{1}{p^2}-\frac{1}{q^2}\right) \frac{\rho}{\Delta E_0} \times 10^{-14}$ $\times 10^{12}$	erg^{-1}	
8	7	6	11615	69690	2	1	16.5	0.06
7	6	10	1293	12930	3	2	3.06	0.06
6	5	16	324	5184	4	3	1.07	0.052
5	4	24	116	2784	5	4	0.495	0.045
4	3	32	51.57	1650	6	5	0.269	0.041
3	2	32	26.29	841	7	6	0.162	0.049
2	1	0	14.93	0	8	7	0.105	—

For $\rho = 1 \times 10^6$ and Cardinality 8 i.e. Quantum Number 1, $\Delta\lambda$ the spectral width comes out to be $1.17 \times 10^{-4} \text{ \AA}$, which is the value given by Quantum Mechanics.

It is known that the Hydrogen lines are grouped in various series such as Lyman, Balmer, Paschen, etc. It, therefore, suggests that ρ and ΔE_0 need not necessarily be constant but can have quantised values. In Fig. 1, $n/2E_n$ is plotted against $-\log E$. The degeneracy of the Hydrogen lines makes it difficult to bring out the changes in the value of ρ and ΔE_0 . But the changes in the slopes are clearly visible as we move from series to series.

Using the equations $\rho/\Delta E_0 = 0.06 \times 10^{14}$ (Table 2); $\rho/8/2^8 = \Delta E_0/E$, $\Delta E_0/E = \Delta\lambda_0/\lambda$ where $\Delta\lambda_0$ is the natural line width, $\Delta\lambda = 1.17 \times 10^{-4} \text{ \AA}$ and $E\lambda = hc$, ρ takes the value of 1×10^{-6} .

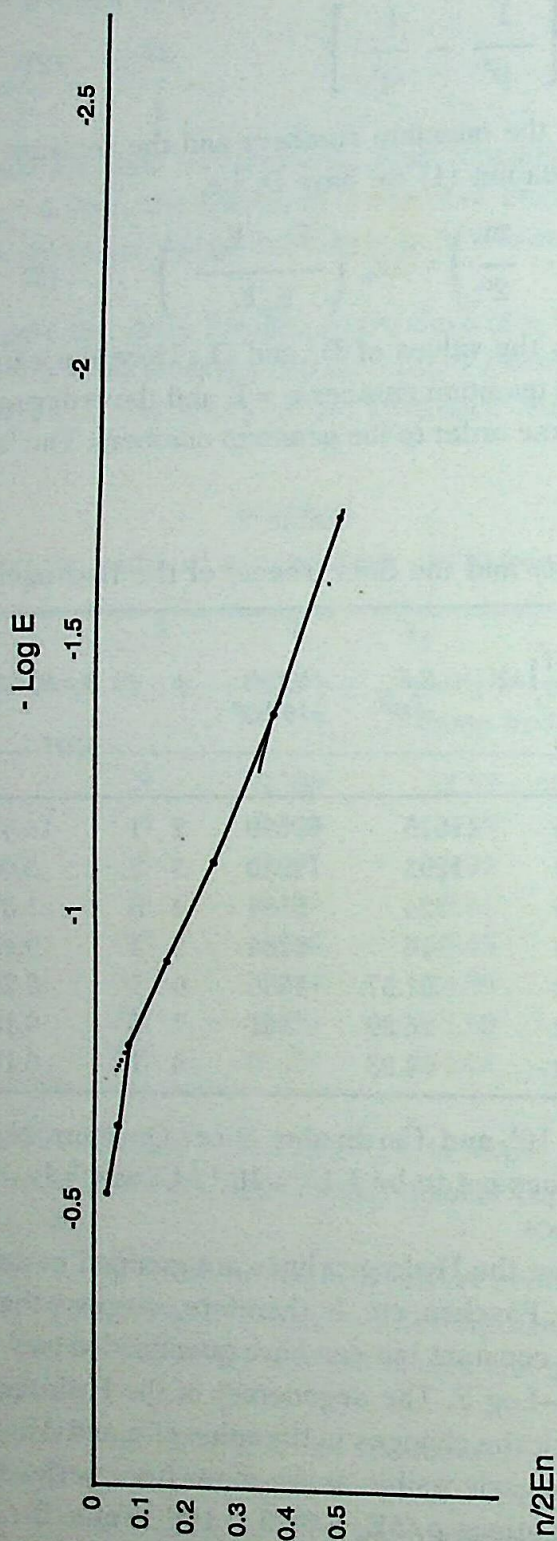


FIG. 1

$-\text{Log } E$ vs. $n/2En$ showing the change in the values of p due to the formation of Lyman, Balmer and Paschen series. The change in the slopes are clearly visible.

This value establishes a consistency between Tables 1 and 2 and also establishes a consistency between the Bohr Theory of the Hydrogen atom and the present work.

We now apply the Cantor Continuum principle to another branch of Physics which deals with elementary particles. Earlier, the energy levels of the Hydrogen atom were considered because of the elementary nature of the particles involved, and the fact that the problem had been solved by Quantum Mechanics and could be used to compare the results of the two theories. The theory of elementary particles concerns problems in the forefront of Physics and a complete solution is far from complete. An attempt is made to derive some order in the distribution of masses of elementary particles as it is essentially a problem of energy levels. The Cantor Continuum principle is so general that it can be used in principle to the study of all physical problems involving discreteness and continuity. It is not possible to apply the present theory to problems where there is close interaction between particles as in the case of nuclear physics, but it could stand a trial with isolated elementary particles.

If T_0 is the lifetime of an elementary particle, its energy width is given by $\hbar/T_0$. If M is the mass of the particle in ergs and C is some constant, we have from Equation 1

$$\Delta E_0/E = \hbar/T_0 M = C \cdot n/2^n$$

Since we know from experimental data, the life-times of many of these particles and their masses, we can determine the values of $C \cdot n/2^n$. By considering different values of the constant C and by selecting the values of the Cardinal number for various values of C , it can be shown that for values of $C = 10E-1$, $C = 10E-8$ and $C = 10E-15$, the values of $\log \hbar/TM$ when plotted against $\log n/2^n$ give straight lines. From Table 3 and in Fig. 2, we can infer the following:

(a) It is possible to see some ordering among the masses and life-times of elementary particles through the choosing of an appropriate cardinal number.

(b) Though the choice of the cardinal number may seem arbitrary, the intercepts of the three lines grouping the particles divide them according to their life-times as follows:

- (1) Those whose life-times are between 1000 Secs. and 10^{-8} Sec.
- (2) Those whose life-times are between 10^{-10} Sec. and 10^{-13} Sec. and
- (3) Those whose life-times are beyond 10^{-17} Sec. and 10^{-24} Sec.

(c) It is seen from Fig 2 and Table 3 that particles described as

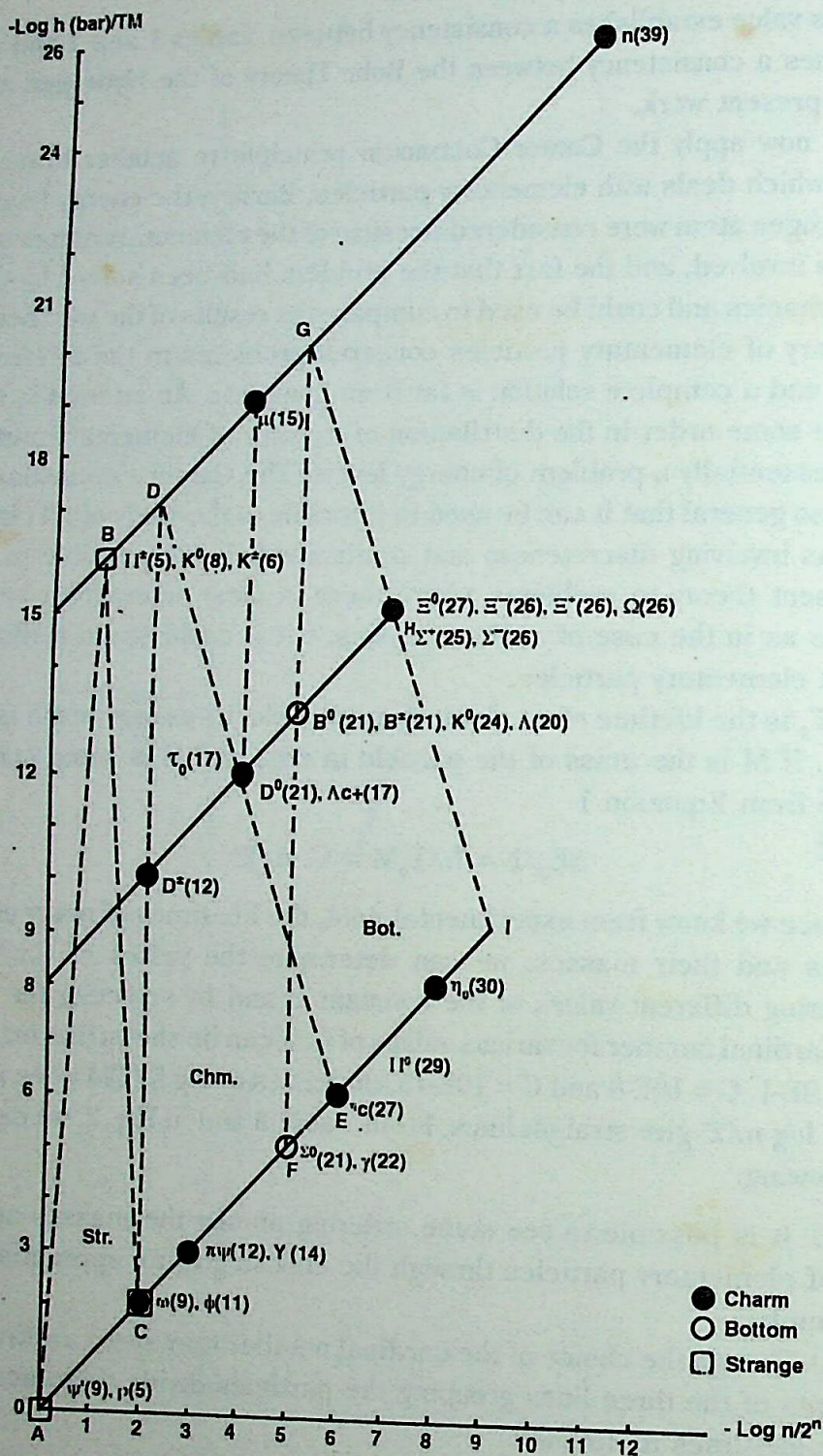


FIG. 2

Families of elementary particle and cardinal number determining discreteness and continuity.
 (Figures in brackets denote Cardinal Numbers)
 For representing the information from Table 3 in this figure the nearest integers have been used for the Log values.

Strange (Str.), Charm (Chm.) and Bottom (Bot.) are found in the sides of triangles ABC, CDE and FGI respectively. It suggests that ψ' should be a strange particle. All particles found at H are Hyperons. One could expect new particles at points marked D, G and I.

(d) The cardinal number by itself represents the overlap of the continuous elements with the discrete elements as given by Equation 1. For example, the neutron has a high cardinal number of 39. This means that its discreteness and thus its identity/reality is well preserved. In the case of those with lower cardinal numbers, further investigation is required to see whether it is possible to connect their interactive properties, implying that a high component of continuous elements implies a greater capability of interaction with other particles leading to a loss of its identity.

It is interesting to note that out of 32 particles, 23 of them fall at points where $-\text{Log}_{10} n/2^n$ (implying $-\text{Log}_{10} \hbar/\text{TM}$) is a prime number. The association of sets of particles with prime numbers leads to a clustering of cardinal numbers around the prime number concerned. Thus, cardinal numbers between 5 and 8, 9 and 12, 14 and 16, 21 and 24, 28 and 30 and 39 and 42 correspond to 1, 2, 3, 5, 7 and 11 respectively.

The significance of these fundamental connections is yet to be investigated.

Real and Virtual Events

We now associate all observable EVENTS with the possible sequence of conditions given by the matrix and associate all VIRTUAL EVENTS, which as we know are predicted by Quantum Theory, with an infinite number of the missing sequences, i.e. those different from the diagonal elements of the matrix.

If all the observable physical EVENTS are described by the elements of the matrix and if all virtual EVENTS are associated with the missing sequences, which now form a set by themselves, it provides for a 'Duality'. This arises because for every REAL EVENT A, there is a VIRTUAL EVENT A', opposite in character, since a one-to-one correlation exists between A and A'. Every sequence in the missing set arises from an element denied in the diagonal set.

Whether the wave and particle nature of matter which are both observable, are found in A or A', depends on whether EVENTS belong to either (A)'s or (A')'s respectively. It also depends on the validity of the Complementarity Principle of Bohr. If particle and wave behaviour are described as both belonging to A only, then the wave and particle property can be observed

simultaneously which is contrary to that predicted by Bohr (Ghose [1992]). If one is from EVENT set A and the other from set A', they will be mutually exclusive.

CONCLUSION

Thus, depending on how we interpret the sequences and the nature of the values of the matrix elements, different kinds of REALITIES begin to emerge. The purpose of the paper is to show that from purely philosophical considerations, it is possible to examine the essential Unity of Reality including Physical Reality. We have shown that by using a matrix, representing CONDITIONED REALITY, it is possible to understand our notions of CAUSALITY and aspects of Relativity and Quantum Mechanics through the use of CARDINALITY and the CONTINUUM theory of Cantor. In a sense it brings the foundations of Physics closer to Godel's Theorem as shown by Weyl (1949), Ramanna (1969), which can also be proved using Cantor's methods.

Table 3
Cardinality and Ordering of Elementary Particles
MESONS & BARYONS

Particle	Mass(m) (in ergs)	Decay time (T) (secs)	$\hbar(\text{bar})/TM$	n	$n/2^n$	C
1. $\Pi^\pm$ Pion	0.2243E-3	2.6E-08	1.8E-16	5	1.5E-1	E-15
2. Π^0 Pion	0.216E-3	8.7E-17	0.56E-7	29	0.54E-7	E-0
3. ρ Meson	1.232E-3	4.3E-24	0.198E-0	5	0.156E-0	E-0
4. ω Meson	1.25E-3	0.67E-22	1.25E-2	9	1.82E-2	E-0
5. μ Meson	0.169E-3	2.197E-6	2.98E-19	15	3.1E-4	E-15
6. τ Meson	2.854E-3	0.3E-12	1.2E-12	17	1.3E-4	E-8
<i>Strange Particles</i>						
7. $K^\pm$ Kaon	0.789E-3	1.24E-8	1.07E-16	6	0.94E-1	E-15
8. ϕ Meson	1.019E-3	1.5E-22	6.869E-3	11	5.0E-3	E-0
9. K^0 Kaon	0.789E-3	5.2E-8	0.25E-16	8	0.31E-1	E-15
		or 8.9E-11	0.15E-13	24	1.43E-6	E-8
<i>Charm Particles</i>						
10. D^0 Meson	2.97E-3	4.4E-13	0.8E-12	21	1.29E-4	E-8
11. $D^\pm$ Meson	2.99E-3	9.2E-13	0.38E-10	12	0.29E-2	E-8
12. η_c Meson	0.876E-3	6.0E-18	0.2E-6	27	0.19E-6	E-0
13. J/ψ Meson	3.097E-3	1.0E-20	3.4E-3	12	2.9E-3	E-0
14. ψ' Meson	3.77E-3	0.26E-22	0.0107E-0	9	0.018E-0	E-0

Bottom

15. $B^{\pm}$ Meson	8.43E-3	14.2E-13	0.88E-13	21	1.0E-5	E-8
16. B^0 Meson	8.44E-3	14.2E-13	0.38E-13	21	1.0E-5	E-8
17. γ Meson	15.13E-3	1.5E-20	0.46E-5	22	0.52E-5	E-0
18. η_0 Meson	5.48E-3	6.0E-18	3.19E-8	30	2.79E-8	E-0
19. n Neutron	1.504E-3	898	7.8E-26	39	7.0E-11	E-15

HYPERONS

20. Λ	1.784E-3	2.6E-10	2.2E-13	20	1.91E-5	E-8
21. Σ^+	1.902E-3	0.8E-10	6.9E-15	25	7.45E-7	E-8
22. Σ^0	1.907E-3	5.8E-20	0.9E-5	21	1.00E-5	E-0
23. Σ^-	1.915E-3	1.48E-10	3.7E-15	26	3.8E-7	E-8
24. Ξ^0	2.103E-3	2.9E-10	1.7E-15	27	2.0E-7	E-8
25. Ξ^-	2.113E-3	1.642E-10	3.0E-15	26	3.8E-7	E-8
26. Ω	2.675E-3	0.822E-10	4.7E-15	26	3.8E-7	E-8
Ξ^+						
27. Λc^+	3.649E-3	2.3E-13	1.2E-12	17	1.29E-4	E-8

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Theory and Practice in Indian Philosophy

J. N. MOHANTY

Writers on Indian philosophy have generally emphasized its practical character. Many have found in this practical character one distinguishing feature, perhaps the most important one, of Indian thought as contrasted with western thought. This alleged practical character itself has been variously identified, the most common understanding being that philosophy in India was motivated by the practical goal of removing suffering (which is taken to characterize human existence) and achieving a state of bliss in a radically transformed existence. In this sense, philosophy is a means to the attainment of that state, otherwise known as *mokṣa*, and not a theoretical enquiry into the nature of things undertaken for its own sake.

This characterization of Indian philosophy has an initial plausibility which however needs to be placed in the right perspective. Unless correctly understood, it is likely to give rise—and has given rise—to a fundamental misunderstanding of the nature of Indian thought. As an example of such misunderstanding, let me quote from no less a philosopher than Edmund Husserl:

Today we have a plethora of works about Indian philosophy, Chinese philosophy, etc. in which these are placed on a plane with Greek philosophy. . . . But only in the Greeks do we have a universal ('cosmological') life-interest in the essentially new form of a purely 'theoretical' attitude.¹

Husserl ascribes to the Indians a 'mythical-practical world-view' but denies that they developed a theoretical attitude. It is therefore a mistake, according to him, to speak of Indian and Chinese philosophy.

Since I am firmly of the view that large segments of Indian philosophy were strictly theoretical, such a consequence as Husserl draws from the alleged practicality of Indian thinking must be due to a misconstrual of that practicality and/or a misconstrual of the relation between theory and practice. A right construal of both, I believe, must satisfy one requirement: it must be able to provide for the possibility of theoretical thinking, while at the same time connecting theory to practice and *vice versa* in an intimate manner.

TWO TEXTS

For a proper understanding of the situation, as it obtained in the classical Indian philosophies, let me begin with quoting, in free English translation, the opening paragraph of Vātsyāyana's commentary on the *Nyāyasūtras*:

Without the means of valid cognition, there is no knowledge of object: without knowledge of the object, there is no success in practical response. The knower, *experiencing* the object with the help of the means of valid cognition, *desires* to acquire the object or to shun it. The effort to acquire or shun the object gives rise to *action*. Success of action consists in relation to the 'fruit' (*phala*). Experiencing the object, the knower, desiring to acquire or shun the object, acquires or shuns it. The object is either pleasure or the cause of pleasure and pain or the cause of pain.²

Knowledge leads to desire, desire to effort, effort to action, action to success or failure (success, if the object has been correctly determined in knowledge). This causal chain, with minor amendations, is recognized in all classical schools of Indian philosophy. We shall try to ascertain what its bearing is on the theory vs. practice questions.

I will now quote another passage which expresses no less a common feature of the classical texts, no matter to which school they belong. Gaṅgeśa, the founder of the Navya-Nyāya school, on the eve of beginning his great work *Tattvacintāmaṇi* offers the following introduction: In order that discerning persons may have interest in studying the work, Gotama laid down the *sūtra*: 'Attainment of the highest good comes from right knowledge. . . .' This is in accordance with the traditional requirement that an author should begin his work by stating not only his subject matter, but also the purpose that will be served by reading the book. The idea is that no discerning person would otherwise want to take pains to study a work unless he knows that it will serve some worthwhile purpose which must be—in the long run—positive happiness or cessation of unhappiness.³ It is not enough if the work simply removes some intellectual muddle or provides some factual information.

I think it would be fairly uncontroversial to claim that these statements by two leading logicians of India—one at the beginning of the Christian era and the other a thousand years later—correctly reflect the Indian attitude towards the relation between theory and practice. But how exactly to understand that attitude?

CLASSIFICATION OF DISCIPLINES

To make some progress towards correctly understanding that relation, let us recall a classification of disciplines or *vidyā*, into four: *trayī*, *vārtā*, *daṇḍanīti* and *ānvīkṣikī*—a classification which is at least as old as Kauṭilya of the fourth century BC. These disciplines are in that order: the science of the Vedas (and accompanying rituals); the sciences of agriculture, animal husbandry, trade and commerce; the science of politics and administration of justice and punishment; and the science which 'illuminates, clarifies all sciences' and is 'the examination of all objects by the application of the *pramāṇas* or means of valid cognition'. Each of the first three is both a theoretical science and a practical canon. But the last one seems to be a purely theoretical science, and the canons, if any, are rather of *theoretical practice* (as in the logic handbooks). But according to Kauṭilya *ānvīkṣikī*, which comes closest than any other designation to what passes as philosophy, also has its practical use: it does good to mankind (*lokasya upakaroti*), 'makes one's intelligence, *buddhi*, settled in the midst of pleasure and pain' and 'makes one an expert, *viśārada*, in wisdom (*prajñā*), in speech (*vākya*) and in action (*kriyā*)'.⁴ The idea seems to be that even the most theoretical of the sciences, *ānvīkṣikī* provides the sciences with their *critical* grounding. All four sciences have their respective practical beneficial consequences.

But merely saying that a science must generate practical benefits of some sort or the other or even saying that the pursuit of science must be motivated by a practical interest is not tantamount to denying the theoretical character of the sciences. The latter denial is a stronger thesis which requires more supporting arguments. One can find three such arguments in Indian philosophy, none universally accepted.

PRACTICALITY OF THEORY: THREE ARGUMENTS

The three arguments I have in mind concern the fundamental concepts of 'object', 'meaning' and 'truth'. First as to 'object': the texts quoted from Vātsyāyana and Gaṅgeśa both use the word *artha*, meaning both the objects to the known and what serves, satisfies or frustrates one's purpose (*arthya*

asau) so that, by definition, the object of knowledge is also that which either causes pleasure or pain. Aren't there objects which are known, but produce neither, objects such as those we perceive but pass by on the roadside without their cognition giving rise to any conative response, positive or negative? Obviously, the authors cited did not intend those objects. They were talking only about those objects whose true cognition gives rise to the highest good—such being the Nyāya 'categories' (listed soon after the first cited texts). The point is that no object is worth enquiry, unless it in some way gives rise to pleasure and removes pain. So the argument from the definition of object (*artha*) carries no weight, it only entails a condition of enquiry—not of objecthood. Metaphysically and epistemologically, it is not surprising that the word *artha* comes to be replaced by the more neutral *viśaya* which does not carry the sense of purposiveness and means simply 'an object of cognition'.

Secondly, as to 'meaning': with the purpose of supporting the thesis that the Vedic scriptures—including the Upaniṣads—do not contain any statements of fact or even any metaphysical statements as to what is real, but contain only sentences enjoining what is or is not to be done, there developed a theory of meaning, later defended by Prabhākara Miśra, to the effect that no sentence is meaningful if it is not a call to undertake or shun some course of action. Such a theory of meaning, if valid, would render all discourse—even seemingly theoretical, descriptive, practical discourse (either explicitly or covertly so). It is as against such a view that Śaṅkara makes his famous distinction between *dharma* and *Brahman*, between *Karma* or action and *jñāna* or knowledge. Since Śaṅkara's words are inimitable, permit me to translate those words:⁵

Dharma has to be brought about (i.e. *bhavya*), it does not exist at the time of enquiry and knowledge; for it depends on effort by a person to be brought about. *Brahman*, on the other hand, is an accomplished reality, not dependent on (any) person's efforts.

Furthermore, Śaṅkara continues, a person can be made to act by a command or an imperative, the words themselves incite the person to act. But to know a thing that is there, there can be no such imperative. Knowledge of a thing arises when the appropriate conditions are satisfied, e.g. when the eyes are in contact with a visual object.

Experience is not the source of our knowledge of what is to be done, verbal instructions are. And an action may be done, or not done, or done in this way rather than that, depending upon the agent's own decision, one may go to a place riding a horse or walking on feet, or in some other way; one

may follow one path rather than another. But regarding a real (*vastu*), one cannot choose if it is or it is not; knowledge of the nature of reality does not depend upon a person's understanding, but rather upon what the thing is like. Of course, a person may *mistake* one thing for another; depending upon the sharpness or dullness of one's intellect or the senses, one may know or perceive a thing clearly or not. But true cognition of a thing must be due to that thing alone. If a thing is F, it has to be known as F. This determination does not hold good in the case of action, where if the agent will do ϕ or not depends upon his choice.

Does this distinction, as formulated, imply that the theory of meaning which reduces all discourse to practical discourse must be rejected? For it may still be held that when A says to B 'That is a snake over there', the sentence is uttered really to caution B, to tell him 'Be careful, don't step on it, etc.' Or, it may be—as young Wittgenstein used to insist—to say 'That is a snake over there' is to make *predictions* about future course of events under specifiable conditions ('if you poke it with a stick, it will move away'). But note that predictions such as these do not take you into practical discourse, even if the antecedent specifies things you may want to do. Construing the utterance as a caution or as an invocation to act in a certain manner is, however to make practical discourse. But what is doubtful is—and Śāṅkara's distinction, if valid, makes us doubt—if the meaning of the sentence 'That is a snake over there' is *reducible* to practical sentences of the sort adduced. One should distinguish between the utterance of the sentence in a given situation, and the *meaning* of the sentence, and then say that it is the utterance in a given context, with a certain *force*, etc., which amounts to a caution, a warning, etc. But what the sentence—not its utterance—means is not practical but theoretical.

The third way one may want to reduce theoretical discourse to the practical is by insisting that for Indian philosophers, irrespective of their school-affiliations, truth is (identical with, not merely testified by) the property of leading to successful practice. Such an extreme view, proposed by Karl Potter, is in consonance with, and may be used to sustain the view being examined, namely, that Indian philosophical thinking has always been practical in its orientation. However, I do not think that interpretation of the Indian conception of truth is tenable, as I have argued elsewhere.⁶ The property of leading to successful practice is rather a test of truth, not its nature according to most schools of Indian philosophy. Only the Buddhist who distinguishes between two orders of truth and who regards all conceptual, linguistic, cognitions to be false, nevertheless, when confronted with the

need for distinguishing between true and false conceptual and linguistic cognitions, advances the theory that for such cognitions that distinction is only pragmatic and not ontological.

So, what is at stake is not the mere possibility or even, in some sense the necessity of practical use of theory. What is at stake is, if there is no pure theoretical cognition and discourse my claim is that the nature of Indian philosophy is profoundly misunderstood if it is not recognized that much of it, at its best, was purely theoretical. At the same time, the Indian mind assumed, almost *a priori*, that knowledge of truth must be practically beneficial. But this assumption should not be construed as entailing that there is no theoretical cognition, on the contrary, the assumption presupposes that there is such cognition.

If in Vedānta, Sāṃkhya and much of Buddhism, it was held that knowledge of reality, by dispelling ignorance, shall remove suffering, it is important to reiterate that it is *knowledge* that they were talking about. For only knowledge can remove ignorance—no amount of *practice* can. If someone insists that the saving knowledge is not theoretical knowledge but intuitive, experiential knowledge in some sense—he misses the point of introducing that distinction. That distinction is not the one that concerns me here. That distinction is within the theoretical—it is between a conceptual and a non-conceptual, intuitive, cognition. The latter is no less *theoretical*, as a matter of fact is closer to the original Greek sense of *theoria*. The seemingly paradoxical nature of the claim is rather this: a purely *theoretical* cognition *will lead to* the satisfaction of the highest *practical* interest.⁷ Besides, the thought of such practical interest may motivate theoretical enquiry, but will never *constitute* it.

THEORY OF PRACTICE

If theory, on the Indian view, is irreducible to practice, the Hindu mind was rather constantly engaged in theorizing about practice. In order to substantiate this last claim, I will draw attention to various features of Indian thought.

Let me begin with the well-known idea—which goes back to the Epic Mahābhārata at the latest—that there are four goals which men as a matter of fact pursue in life (*not*, to be sure, they ought to be pursuing): *Kāma* or sensuous pleasure, *artha* or wealth, *dharma* or righteousness and *mokṣa* or spiritual freedom. For my present purpose, let me leave aside questions regarding the rank ordering amongst them and transition from one to the other. What is noteworthy, in our present context, is that with this conception in place, Hindu authors hastened to theorize about them and to compose

scientific treatises on each. Thus we have Vātsyāyana's *Kāmasūtra*, Kauṭilya's *Arthaśāstra*, Jaiminī's *Dharmaśāstra* (and many other treatises on *dharma*) and Bādarāyaṇa's *Brahmasūtra* (which may be called also *mokṣaśāstra*). In these works, the appropriate theme was defined, means to achieving the goal were laid down, and a certain theoretical justification was provided for the entire project. But what sort of theoretical justification?

Let me distinguish between two kinds of thinking about practical matters, e.g. about *dharma*: one I will call dogmatic, and the other *critical*. One can accordingly speak of *dogmatic* practice and *critical* practice. Dogmatic practice (and dogmatic writing on practice) goes by lists (and listings) of duties and virtues: 'one ought to do ϕ ', 'one should not do ψ '. (The distinction between 'should do' and 'ought to do' was not quite clear; in Sanskrit grammar the *vidhiliṅg* expressed both). Many of the *dharmaśāstras* did the listings, classified them according to castes, stages of a person's life (whether one is a young student, a married householder, a retired knowledge-seeker or a wandering mendicant), or with regard to one's relation to others (to members of one's family, to other castes, to the community at large, to the king, to the holymen).

Critical thinking about practice asks the following sorts of questions: how are the words of the texts which are supposed to prescribe the duties and virtues (and prohibit their opposites) to be *interpreted*? This gave rise to large hermeneutic issues about principles of interpretation, about priority of word-meaning or sentence-meaning, issues about holism (is a sentence the smallest indivisible unit or is the entire text an indivisible unit?) What are the roles of context, beginning, end, repetition of texts, of author's intention, of direct meaning and indirect, implied and suggested meanings? How is the list to be legitimized? What is the source of authority and competence of the author, if there is any? What other sources are there, besides textual, for our knowledge of do's and don'ts? These hermeneutic and epistemological questions are not the only theoretical questions to be settled. *Practically* more important is the following question: Is it enough, from a moral point of view, to do one's duty, or is it required that the agent must be doing his duty in *a certain manner*, with a certain attitude, in a certain spirit? Also the question: is *dharma*, righteousness, living in accordance with the prescribed and the prohibited, *a necessary means* to *mokṣa* or spiritual freedom, and if so, why? Answers to these questions are based as much on hermeneutic exegesis of the appropriate texts, as on philosophical, especially metaphysical, grounds.

To take an example: one of the large divides is between those who, as in the Nyāya texts quoted earlier, hold that all action is motivated by the

desire for acquiring and augmenting happiness and getting rid of decreasing pain, and those who, like Bādari in antiquity and following Bādari Śrī-kṛṣṇa of the *Bhagavadgītā*, insisted that duties have to be done for their own sake, and not for any consequences that may accrue from doing them. It is the distinction, familiar in western moral philosophy, between the consequentialists (such as Mill) and the Kantian-type deontologists. The consequentialists appeal to human psychology; the deontologists to a metaphysics of self in contra-distinction from nature (as Kṛṣṇa does in the *Gītā*). Both, the Naiyāyikas and the followers of Bādari, notably Prabhākara, also appeal to hermeneutic principles with reference to Vedic texts such as *svargakāmo yajeta*. The psychological issue is: can a person be incited to act simply by the linguistic form of an imperative, or does he need to be motivated by desire for happiness etc.? The metaphysical question is: is the true self of a person a natural entity, subject to natural attractions and repulsions; or is the true self a pure spirit who stands above the mechanism of nature? Ethics is sought to be grounded (a) in a hermeneutic of injunctive sentences, (b) in a psychological theory regarding how the human mind works, and (c) in a metaphysics of the self.

A person who strives to abide by the values of *dharma* but in a spirit of selflessness, without aiming at more pleasure and less pain and has satisfied himself with good reasons as to why he should do so, I would characterize as being engaged, not in dogmatic, but in *critical practice*. He is acting in accordance with rules of morality and also in accordance with a *theoretical* belief. He is not simply following a list.

But does he need to accept *all* the rules laid down in the *Dharmaśāstras*? Critical thinking about the *given* rules of practice is not truly critical as long as its only task is legitimization and the only attitude is abiding by them in a spirit of detachment. One must also be able to critique those rules and their presuppositions, and, if needed, to reject some and amend others. Only you cannot wholesale reject them, as you cannot wholesale abandon (Neurath's) leaking ship in mid-ocean, you can only repair it plank by plank. This the Indian thinkers did in various ways—sometimes by adding or deleting, sometimes by amending given rules, by adding new conditions and limits, but most remarkably by *re-interpreting* old texts. A good example of changing bits and pieces of the given ethos by re-interpreting is to be found in the *Bhagavadgītā*, where the ritualistic key term *yajña* (or fire sacrifice) is given a symbolic-psychological interpretation. The same can be said of Gandhi's reinterpretation, in more recent times, of the idea of *varṇa* (or color), traditionally understood as caste. The Hindu *Sittlichkeit* has proved itself to be capable of change from within.⁸

THEORY AND PRACTICE

There is a certain way of understanding the relation between the two, theory and practice, which is that practice is the application or use of theory. In the context of Indian philosophy, this amounts to saying—what is its equivalent—that, in Indian philosophy, philosophy is not merely a theory, if theory it is, but is also an application of theory to practical life.

The very idea of *applying* a theory to the particular situation with which practice deals is not, by itself, a very clear notion. Aristotle, with his conception of *theoria* as contemplation of unchanging truths, did not find it possible to give any clear account of how it is to be applied to the particular changing situation, and appealed to *phronesis* or 'practical wisdom' which could best be learnt in appropriate examples but for which no rules could be advanced.

When it is said and claimed that the Indian philosophies are meant to be practical, transformative of life and existence, what is meant is possibly different from what is meant when one speaks of applying a theory to a practical situation. What is meant is not that the theory is applied (as pure science supposedly in technology), but *possibly that the theory itself is not a pure theory but a practical theory*. But what could that mean? In order to understand this claim, let me recall Hans Jonas's distinction between the antique, classical, notion of theory and the modern post-Baconian scientific idea of theory.⁹ The classical Greek theory consisted in contemplation of the unchanging essences of things, of things that are themselves 'noble' and 'higher' than man in the ontological hierarchy of things. Such contemplation, besides providing man with the ultimate goals or ends or values to be pursued, produced nobility and happiness in the souls of those who were engaged in it. The modern theory, since Bacon's time, is concerned not with those unchanging essences, but with actions and causes of elements of nature with entities which are 'lower' than man and so is incapable of providing man with ultimate ends of life. However, being itself technological in nature, modern theory is not contemplative but consists in manipulation of nature, so that practice is not extrinsic but, rather intrinsic to it. In Jonas's words, it looks at nature qua acting, and achieves knowledge of nature's laws of action by itself engaging nature in action—that is, in experiment. Its 'fruits' are generated not in the soul of the knower, the scientist, but 'for his not-knowing fellowmen'.¹⁰ Charity, benevolence and compassion are not fruits of modern theory, for its objects are all for use, and lack the nobility of the objects of classical *theoria*. Again in Jonas's words, 'Theory itself has become a function of use as much as use a function of theory'.¹¹

If Jonas is right, then Husserl too is right in thinking that modern science falls short of the Greek ideal of *theoria*; but Husserl must be wrong in not recognizing that with modern science a *new* conception of theory had come into being (one which is not simply a corruption of the original), *whose connection with use and practice is internal and not extrinsic*, which is as much cognitive as manipulative of nature. Heidegger is right in emphasizing this modern break with the classical antiquity.

How then are we to evaluate Husserl's remark that the Indians did not have a concept of pure theory inasmuch as they conceived of thinking as a means to solve ultimate practical questions? If Husserl was at this point wrong, is it because the Indian *theoria* was closer to the Greek or is it because in its practical orientation it was an anticipation of the Baconian ideal that knowledge is power? Was its subject matter something unchanging and so 'nobler' than man, or was its subject matter the sundry things of use (the *Gebrauchsdinge*) which are 'lower' than man?

From the very beginning, philosophy in India had for the object of contemplation either the unchanging *ātman* which was the essence of all things, or the *Prakṛti*, the Ur-Nature out of which all things have arisen—in any case, the One behind the many; and, it may also be, that from the earliest phases of the Brahmanic culture, certain forms of spiritual-ascetic practices and technology developed with a view to acquiring power (*tapas*) over courses of nature and over the course of one's inner mental life. The two—the contemplative course and the practical-technological course—must have at some phase of each mingled, and were attuned to serve each other's purpose: the *theoria* to provide a conceptual underpinning for the practice and the practice to serve as the theory's application to life. Look at the way the idea of *yoga* was made to serve every conceivable theoretical position, to rescue each from its mere theoreticity and to claim to be able to transform it into a corresponding living experience. Even the Nyāya-Vaiśeṣika, a realistic and pluralistic metaphysics, concerned itself with such essences as 'substance-hood', 'quality-hood', 'action-hood', also with universality, particularity, inherence as a relation, and absence-hood—leaving the particular instantiations (such as *this* tree over there) to everyday, pre-philosophical concern. So one could say, with Jonas, that the objects of Indian philosophical thinking are *real* essences—unchanging and eternal, 'nobler' than the empirical mortal human, but on a par with his imperishable soul. The felicity that is supposed to arise from such philosophical cognition must inhere in the cognizer's own soul; the same holds good of the 'power' that is supposed to accrue from *yogic* practices—still far removed from the Baconian ideal that knowledge of nature is to benefit the not-knowing fellow humans as well.

What Hans Jonas's distinction does not bring out is that besides the two—the ancient Greek and the modern Baconian—there is a third concept of theory. On this third notion, a theory is not simply a contemplation of an unchanging essence or essences; not an experimental science of how the natural causes work; but a *logical structure* of propositions constituting a system, rationally grounded on some self-evident axioms (or propositions *taken to be axioms*), best exemplified at first in Euclidean geometry, but then in formal mathematics. Husserl regarded *this* to be the lofty achievement of western culture, but wanted genuine philosophical theory to be free from the naivete of this formal-deductive theory and to be grounded, in every step of its movement, in a rather Cartesian manner, in intuitive 'seeing'—thereby being able to combine the ancient Greek with the modern *non-Baconian* idea of theory. The need for grounding in intuitive evidence arises from the requirement that theoretical cognition must not be dogmatic but must be radically self-critical. For such self-critical thinking, the question of *beginning* becomes pertinent—leading western philosophy to the magnificent *tour de force* in Hegelian logic and its ultimate collapse with Kierkegaard's questioning if any thinking at all can accommodate within its own, ultimately, existential beginning (and existential end).

In order to understand the nature of Indian philosophical thinking, one must ask: does it exhibit that search for radicalness, for its own beginning, its starting point, which mathematics found in axioms, the Cartesian found in intuitive 'seeing', which eventually Kierkegaard and Nietzsche exposed as having been rooted in a dishonest act of willing?

I cannot take up this large question in this paper. I can only say this much that the Indian philosophical systems, the *darśanas*, when they achieved full theoretical self-consciousness and discursive sophistication, did *not* ask the question about their own beginnings—historical or conceptual. Each arose from a distinct interpretation of the historical tradition, each began with a dogmatic listing of its ontology, each developed into a critical, epistemologically self-reflective theory. But none asked: what is conceptually the first proposition of the theory? Is this first proposition a self-evident truth, or is it to be validated in the same way as the rest of the theory? Consider the Nyāya-Vaiśeṣika. Its list of categories is more or less fixed. Textbooks began with a list. Critical works defended the completeness and adequacy of the list. But how was the list arrived at? One invariably goes back to the authority of Gotama and Kaṇāda, to the earliest available texts. This is why, sometime back I had remarked: the foundation is not in a first proposition, not in a transcendental subjectivity, but rather in texts. There are texts behind texts.¹² Even critical, discursive theory does not cease to be

hermeneutic of texts. *The last founding for a darsana is a tradition.* Thus while the philosophies are theories, they are neither intuitive, nor axiomatic, nor empirical, but hermeneutic and critical in method—irrespective of their contents and subject matter.

How can such a theory be *realized* in practice? The Greek *theoria* gives rise to *phronesis* or practical wisdom for which no rules can be advanced. The Baconian science itself is experimental; its application consists in repeating, with regard to natural elements, the very same steps as are taken in the experimental set up. The purely deductive sciences are applicable in as much as their uninterpreted terms are given interpretations in terms of concepts which are *idealizations* of empirical phenomena. In this last case, *the applicability itself is a matter of a second-level theory*; actual application in a particular case is quite another matter.

Application of a theory to nature, and application to and relevance for human practice are totally different things. The Greek *theoria* had relevance for human action by supplying the conception of ultimate ends. The relevance of Baconian science and of the mathematical sciences for human practice is doubtful. Each Indian philosophy provided an ultimate end—or rather a version of the ultimate end to be pursued, i.e. its own version of *mokṣa* or 'spiritual freedom' as well as a *general* account of the *path* to be followed—in terms of its own metaphysics and epistemology. In each case, the *actual* means to be adopted for a *specific* individual was left to many variables, *not specifiable in advance*.

But it was not simply a trait of character—charity, benevolence or wisdom—that the Indian theories promised would follow from the knowledge of their truths. What was claimed was a total and radical transformation of one's ordinary being-in-the-world, freedom from the fetters of the claim of rebirth and *karma*, a cessation of all pain and suffering, possibly, an everlasting felicity of being. How could such gains accrue from *philosophical* cognition, and what sort of cognition it must be if it can result in such radical transformation of being? What is being promised is neither Aristotelian *phronesis* nor Jonas's 'nobility'. Can theoretical knowledge yield such consequences?

Several responses can be made to this question. Parts of almost every theory are indifferent to that grand goal: these are the many logical, epistemological, and semantic theses which every theory defends on issues which are *prima facie* far removed from the large claim made on behalf of the system as a whole. In the second place, in a logical system such as the Nyāya the 'founder', Gotama, appears to have that grand vision, claiming

that knowledge of the ontological categories of the system would lead to 'freedom from suffering', while as the system develops and becomes discursively more sophisticated that claim recedes to the background—to be sure, never rejected altogether—and the conceptual issues become increasingly more important. It is in the so-called *ādhyātmika* or spiritual systems such as Sāṃkhya-Yoga, Vedānta and Buddhism, that the 'transformative goal' predominates—even when the systems relentlessly strive after providing their systems with secure discursive foundations. It is in these systems that *paths* are laid down, which allegedly 'transform' the purely discursive understanding to an 'intuitive realization'—paths of meditation, more specifically.

Now it is often not clearly noticed that pursuing such paths—meditating, etc.—is not *eo ipso* continuing to do philosophy even of the system to which the path concerned is affixed. Philosophy is a discursive theory. The putative 'path' is intended to 'transform' the discursive philosophical knowledge into a non-discursive, intuitive knowledge (if knowledge that is to be) or experience. If theoretical, discursive knowledge cannot yield the consequences that we are promised—as it clearly cannot and does not—then the putative 'realization' does. But we still have to make sense of the idea of an intuitive 'realization' of a conceptual truth, which is not an easy task. Even if one makes sense of this claim, one has to make sense of the other part of the claim, namely that such intuitive experience would 'free' you from the chain of rebirth, from so fundamental a human predicament as being-in-the-world, from all pain and suffering. I have grave doubts if we even understand the claim. There is a familiar metaphysical thesis which is made to support the claim: the thesis, namely, that the human predicament is due to *ignorance* of the metaphysical truth as formulated in the theory. In that case, the claim of course follows by analytic necessity.

We thus see that the putative *practicality*, at least in the senses formulated, is misleading, to say the least. The practical 'path' does not follow from the theory, but is added on to it, and must have had a different and independent origin.

PRACTICE AND PRAXIS, DHARMA AND MOKṢA

The domain of practice, in the true sense, is that of individual and social morality i.e. *dharma*. The large doctrine of *dharma* in its endless ramifications is what regulates Hindu practical life, gives it a centre and its norms, holds society together, and even exercised sway over politics. The Indian

philosophical theories left it untouched, did not want to provide *dharma* with a foundation, they all, excepting the *Mīmāṃsā*, aimed at being theories in *mokṣa* instead. As a consequence, they used it as means to *mokṣa*, and added to it *ab extra*, in consonance with their respective metaphysical views, the need for being free from 'attachment' to the 'fruits' of action (thereby making it allegedly a fit means for *mokṣa*). But a critique of *dharma* in the truly philosophical sense was not called for—which confirms my suspicion that *philosophy's concern with dharma was minimal. Philosophy just found dharma as given.* Today, Indian philosophy needs to be a *critique of dharma*, without which the practicality that is claimed on its behalf by its modern exponents would be nothing but pretentious.

Such a critique would be epistemological, hermeneutic, moral and political. The epistemological question would be: what are the valid means or *pramāṇas*, for determining what is and what is not *dharma*? The hermeneutic critique would examine available interpretations of the texts, and examine their strengths and weaknesses, and—if necessary—advance new interpretations. A moral critique would attempt what is perhaps the most difficult: to subject the handed down ethical codes (*Sittlichkeit*) to a moral test. The very idea of doing this is likely to be controversial, and it can very well be risky. Can our present day moral conscience sit in judgment on the traditional ethos? We cannot also avoid a political critique. The place of politics in the Hindu theory of *dharma* is hardly recognized and likely to be controversial. Is it only a part of it, the part which concerns the king and the warriors? But that can be true only on a narrow construal of 'politics'. If politics is concerned with *power*, and the *dharma*-doctrine with its hierarchical mode of thinking involves, presupposes and supports a certain hierarchical distribution of power, it is—much against its own self-understanding—profoundly political and invites a political critique. In our present context, it is also important to ask: how a non-hierarchical metaphysical theory could possibly generate a hierarchical *dharma*-theory—a question which would support my suggestion that the political theory had a different and independent origin.

I will conclude this paper by commenting briefly on some of these issues and by answering one possible, and fundamental, objection to the position advanced in this paper.

Firstly, the epistemological question concerning the means of determining what are the *dharma*s (what we ought to do) and the hermeneutic question about how to interpret the texts, are inseparable in the Hindu context. They are inseparable, for on the Hindu theory, *dharma* can be

ascertained neither by perception nor by inference, but rather only by *śabda*, i.e. the 'words' (the texts primarily, verbal instruction derivatively). The rationality of this theory is the same as that of the claim that the *ought* can neither be perceived as a fact, nor be deduced from purely factual premises. It is only by 'hearing' the imperative 'you ought to do ϕ ' that one gathers 'one ought to do ϕ ', provided one believes in the moral and intellectual 'competence' (and so reliability) of the speaker. However, this entails 'interpreting' the words heard (or read), and so hermeneutic questions are unavoidable.

Secondly, as against a possible moral critique of the *dharma* doctrine, one may raise the following objection (a la Hegel): the critique confronts individual conscience with what is handed down through history (as 'objective spirit'), and it is only pride and arrogance which can allow the individual to sit in judgment on the tradition. Following Gadamer one may add: the critique claims to be able to judge tradition from above, from a point of view which is not corrupted by any tradition as though he/she were a pure transcendental ego—whereas, as a matter of fact, the critic's concerns are always within another tradition, from another historical/cultural vantage point. If this is so, then it is one tradition vs. another, rather than individual conscience vs. tradition. This is the reason, the Hindu tradition welcomed internal critique, not external critique. But the difficulty is that a strict line of distinction just cannot be drawn between internal and external critiques. Is a critique of caste which appeals to the idea of equality of all men external and is a critique which regards caste distinctions incompatible with the thesis of the scriptures that one universal self is in all beings an internal critique? In fine, as Gadamer held in response to Habermas, internal critique 'reinterprets', external critique does not have the patience to do that. Is all internal critique hermeneutic?, we still need to ask. Shall it always be gentle and patient, and never be impatient and radical? Is this itself an ethical decision sanctioned by the tradition to perpetuate its power? At this point, the political critique becomes relevant. For the Hindu, *dharma* tradition was not politically neutral, it did defend a sort of monarchical system (even if the king's power could be superseded, in case of conflict, by the moral consideration), so it cannot be immune to a critique which reflects on the nature, concentration and distribution of power.

RETURN TO THEORY AND PRACTICE

Integrating theory and practice, belief and life, is an ideal cherished by thinkers and ordinary persons alike. But how to achieve such integration?

Three strategies are open: you provide your practical precepts with a theoretical foundation. Or, you *deduce* your practice from a coherent theory. Or, you *apply* your theory to life. The last is what we generally expect, but we are not clear as to what 'applying' means here and what the conditions of application are. We may need a second-level theory for applicability, and leave the *actual* application to *phronesis* or practical wisdom to be learnt from examples. The first two strategies have interested philosophers. It is often questioned if the Indian philosophers ever did any of these. I think they did the first in a curious manner, not by providing all ethical rules with a theoretical basis, but by grounding the idea of 'non-attachment' or 'selflessness' in certain large metaphysical theses (such as the identity of self in all being, or the fundamental distinction between self and Nature as in Sāmkhya and Gītā), but in that case it is not *dharma*, the *Sittlichkeit*, that is so grounded, but the idea of *dharma as means to mokṣa* (for *dharma* leads to *mokṣa only when performed with 'non-attachment'*). The second strategy is more often proclaimed than executed. Kant came nearest to the program by asking, 'How can reason be practical?' But he too presupposed a *given* system of morals, and at the most thought that reason, in the form of the categorical imperatives, can *test* the given moral rules and validate their credentials—not deduce them from within itself. Nor did the Hindu theorists do any better.

What theory does, at its best, is to *reinterpret practice in its discourse*, and thereby to seek to *appropriate* it as its extension, its application, its actualization. *Theory thus proclaims and establishes its sovereignty*, and *accords to practice the dignity of realizing the theory*. This is as much true of Marx's idea of realizing Hegelian theory as of the Indian claim to be able to realize Vedānta in life. Practice is still made a handmaid to a comprehensive theory which sets the goal, legitimizes the goal as well as the means, demonstrates its realizability. The rest is outside the domain of philosophy.

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History of Science and Two Metamorphoses of Mind

P. K. MUKHOPADHYAY

I

It is a sad but sanguine situation when the members of a living culture experience crisis of identity, articulate the experience and seriously endeavour to discover or rediscover the lost or blurred identity. Such a situation is prevailing in India for quite some time. Many attempts have been made in the past and many more attempts are being made today to rediscover our cultural identity. The problem and the measure to be adopted to solve it are clear in their general outline. We are to study and understand India's past with a view to revitalise our theoretical culture or ensure fresh creativity. Along with or independently of it we may initiate serious research directly into the foundations of theoretical sciences in Indian tradition, discover the fundamental insights, methods and issues to be found there and assess their validity, potentiality and present day relevance by contemporary standard. I have spoken elsewhere about this second kind of project. In the present paper I shall confine myself to the former kind of projects which distinguish themselves by their explicit historical approach. One such project which has recently been launched officially is the Project of History of Indian Science, Philosophy and Culture (PHISPC).¹

I am neither a historian nor a scientist; nor do I have any desire to trespass into the territory of others. The statements made here may for the present be taken even as personal response to the situation noted above as prevailing in India. These constitute at the same time a preemptive response to otherwise not wholly unjustified belief that India is an over

exposed subject, a well explored topic. If we do not make an issue of the way historical and indological studies have largely been conducted so far, much has already been done in the areas which come within the scope of these projects like PHISPC. We should be very clear as to what still remains to be done. Much has been said in the beautifully produced booklet which contains the PHISPC proposal and many copies of which have been distributed among the scholars. But so far as these projects relate to Indian science and aim at studying it against the broad cultural background, much is there left to be done. For example, a science or scientific theory usually has three aspects—a set of doctrines, a set of concepts, and certain theory of rationality and/or methodology. So far as Indian sciences are concerned, much less work has been done to explicate if and what distinctive theory of (scientific) rationality India had than to study the other two aspects of sciences.

I would like to emphasize further that the way their own history is available to the members of a society is not the way the history of a different society is available to them. The type of history that we need and which can satisfy us when the subject is a different society may not be needed or considered satisfactory when our own culture is in question. History is supposed to compensate for the lack, on the part of a society, of organic memory which human individuals have. Such history is written in academies. But people write their own history by allowing their present thinking, activity, speech and every aspect of life to be determined by what have gone before. There are different ways of articulating and recording the past; explicit consciousness in the form of memory or self knowledge is neither necessary nor to be had actually. History available in the form of the mind of a people, shaped in a certain way, and shaping itself constantly by selecting, rejecting, responding to and thereby producing the world it inhabits needs to be articulated. This history remains somewhat constant or always available amidst all the changes the conception of history undergoes. The foreign and spurious elements that have occasionally gone into the shaping and distorting the mind and preventing the clear projection of its own image are to be identified and if possible eradicated.

II

Did India have science of her own? What science, if any, developed in India? Perhaps these are conventional historical questions; to these there are positive answers which are generally known and accepted. So far no great

need is felt for undertaking new and costly projects of history if those are aimed at merely reasserting known and accepted truths or discovering simply new details. It may be more important and interesting if historical research is undertaken to find out whether, why and by whom the allegedly agreed positive answer to the question was challenged. For record tells us that a bishop in the mid-seventh century thought it proper to remark, while comparing favourably the achievements of the Hindu Mathematicians with those of their Greek and Babylonian counterparts, that 'If those who believe, because they speak Greek, that they have reached the limits of science, should know these things (astronomical discoveries and methods of calculation of the Hindus), they would be convinced that there are also others who know something.'² But it may be better to assume that the bishop was not answering a challenge but taking cognizance of his new discovery, namely, India with her great scientific heritage and achievements.

It is more important to note that while all these are known and even while tracing West's will to science to similar will of the Greeks, the modern West believes that science is the production of Western civilization. How the Westerners reconcile this belief with known historical facts is also well known. It is the thesis of intervening dark ages which separated Western scientific culture from the Hellenistic culture on the one hand and from the Indian (Vaidika) and Chinese cultures on the other. Opinions differ as to why such a dark age had to intervene. Even though this question has not been satisfactorily answered, George Saroton seems to think that so far as science of India is concerned this dark age began after the twelfth century when the Muslims destroyed whatever there was and did not encourage new development.³ Some Indian historians of science hold more unhistorical and unjustified belief; according to them one, perhaps the major, cause of decline of scientific culture in India was the development of (*advaita*) Vedānta philosophy.⁴ Even if these explanations had any historical truth about them, these and similar historical findings seem to have little value in respect of current relevance or future planning at any given time, including the time when India's science and technology policy was framed, as reflected in the Scientific Policy Resolution which Indian Parliament passed in 1958. For one thing, no one can undo either the havoc wrought on India's intellectual progress by the plunderer or the glory added to it by the Vedantic savants. J. Needham's *Science and Civilization in China* may have already produced some effect. But that is limited to the beliefs and practices of only some European historians of science who most probably knew already that in spite of its dominance Euro-Centric conceptual frame work was never valid for science as such.

What however I consider to be most important for the moment and to which the projects like PHISPC as well as the project which started a little earlier—Foundations and Methodology of Theoretical Sciences in Indian Tradition (FAMTSIT)— can jointly contribute and can do so most richly if properly coordinated, is how to understand (and thereby help people transcend or undo) the two metamorphoses of mind, one which shaped and has been sustaining the modern Western culture and the other which India suffered under the impact of the advent of the West. This understanding should be allowed to shape our approach to PHISPC, at least so far as history of Indian science part of it is concerned.

The study of these metamorphoses of minds will convince us that what determined the civilization of the west to become a scientific civilization was not so much the facts of history—the actual scientific achievements of the Europeans. It is rather the way those facts were emotionally and culturally appropriated by the people of the West which created in the mind of the Europeans the conviction that science is essentially an European product. The cultural appropriation of the title scientific and proud identification with science gave spurt to the growth of science in the West. A typically candid account by a Westerner would read something like this 'Science is important to us, not only because of the knowledge it brings, or because of what it enables us to accomplish, but also because it is effecting an even more penetrating metamorphosis of the mind'.⁵ A component as well as consequence of this metamorphosis is this special way of looking at science. 'Science can today be seen to be the most typical creation of thought of this (Western) civilization, just as it has become the most indispensable tool of its enterprise—daily life is permeated with the ideas of those who crusaded for consolidation of the practice of science among all sorts of conditions of people. Something most extraordinary would have to happen now to jeopardize the position it has won for itself.' 'But to say that science has become one of the major intellectual occupations of Western civilization, as well as earning its daily bread, is not sufficient to define with accuracy what is special about our present situation, nor even to give a fair characterization of the role science plays in it. Science is important . . . metamorphosis of the mind.'⁶ I shall speak a little more about this metamorphosis later.

The reported metamorphosis and the account of it to be sketched here may not be strictly historical as the term is conventionally understood. But such a view of science and its role in society and life of the individuals have been most effective in determining West's attitude both to itself and to other countries including the East in general and India in particular. It would not in itself be of great consequence for us even if this Western attitude were

authentic, even if the Western civilization were scientific and Indian civilization were not so. But two points may be properly appreciated in order to give right direction to the sort of projects under reference and turn them useful. The metamorphosis of the Western mind (in question) became effective as one of the contributing factors in another metamorphosis of mind. I shall presently offer an idealized and oversimplified account of this metamorphosis of mind which India actually suffered. This time the beliefs constitutive of and consequent upon this metamorphosis were still less authentic. To say this is not to suggest that this belief was any the less effective. In fact this belief that India is a non-scientific spiritualistic culture has created, even if unarticulated, a certain scepticism in the minds of Indians. People have become conditioned to think that any search to rediscover and promote Indian science is futile. Unless a historical project is consciously geared to the task of correcting and removing this scepticism it will not be able to lay the real foundation of or encourage serious effort towards rediscovering and rebuilding, scientific India. Moreover the suspicion of anachronism, bias and preferred interpretation cannot be effectively answered whenever we claim to have discovered evidence of science and technology in some archaeological and other types of findings. Science is not just a matter of stray statements or inscriptions, tools or formula. It is a matter of idea and attitude; of feeling, dream and aspirations. Till we can effectively argue from the findings, which by themselves do not speak, to the mind behind them—unless we can convince ourselves that our ancestors themselves produced in course of their conscious scientific endeavour those in which we are inclined to find evidence of a scientific culture, exercise in historical research is of little value outside the discipline of history in the narrow sense. What we need therefore is not so much the facts of narrative history as the felt history ever in the making. Had there been extremely discerning observer there at the time he would have witnessed how during the colonial rule Indian mind underwent gradual metamorphosis.⁷

The belief supported by and lending credence to such transformation, that India is essentially spiritualistic, could not sustain it or make it effective in practice. No hitherto unattained spiritual height was achieved during nineteenth or twentieth century in literature, philosophy, or social or moral institution. For the belief was inauthentic. Such a belief can be negatively effective in stalling the progress along the indigenous line but cannot initiate new movement or ensure progress along a different line. Neither a dead history nor a living history of only actual beliefs which, as in case of India, are artificially induced, can be positively effective. But if objective ingredients of a certain culture (say, scientific culture) are available and also

there is conscious identification with and living faith in that culture only then people can become participating and contributing members of that culture. This was exactly what happened in case of the modern West. To turn the people of India into participating member of scientific culture in this sense of the term is to ensure cultural promotion and progress.

But why the Indian culture has to be a scientific culture? One answer is that the question does not arise, because it, as a matter of fact, is so. The other more important point is that to realize it to be so is at the same time clarifying to ourselves what science is. Without a clear understanding of what science and scientific culture are the projects of history of Indian science can not really start nor can they have well defined direction. If on the other hand, such understanding, which one can expect to result from the works under such projects, does not enable us to rediscover our cultural identity or ensure India's intellectual cultural progress then the projects will lack much of their value. Again we do believe that Indian culture is scientific; for there is a sense in which not to be scientific means to be mystical, esoteric, irrational and faith, habit or superstition ridden. India had never been such.

There is the other side of the picture. Even in a much narrower sense of it science is believed to be the whole of knowledge and this notwithstanding Russell's remark in 1935 that Canon Streeter was uttering a truism when he said 'science is not enough'. Actually Canon Streeter was challenging the rationalist tradition of seventeenth and eighteenth-century Europe in which it was not a truism.⁸ Even as recently as in 1979 Hilary Putnam could not help writing 'But there is a tradition with which I do not wish to be identified, which would say that scientific knowledge is all man's knowledge.'⁹ Thus if one component of the metamorphosis of Western mind had been the belief that science is essentially the product of Western civilization the other component belief had been that science constitutes the whole of man's rational and theoretical culture. Science sets the norm and criterion of theoretical (as well as perhaps practical) rationality. This resulted in the West's abiding concern, how science could be distinguished from non-science and pseudo-science. Science-Philosophy dichotomy is wholly a product of the West, whether or not science is solely its creation. India suffered in the nineteenth century the metamorphosis of mind when it came face to face with the Western mind so metamorphosed by science. It may as well be said that this picture or image of the West got sharply delineated, this cultural bias and commitment of it got well articulated, in a word Europe discovered itself as what it believes itself to be even as India was suffering the said metamorphosis. It has been rightly remarked by Said¹⁰ that the Orient is not only adjacent to Europe, it is its cultural contestant, its constant

Other; and as such it is an integral part of European civilization and culture. Similarly what the Orient or India is in the eyes of a modern Indian is to a great extent the imagining of the West.

III

I would like to imagine, may be somewhat in the popular sense of the word, the occasion which necessitated West's imagining India and simultaneous metamorphosis of Indian mind somewhat along this line.

Nationalist chauvinism and objective difference make it very hard to arrive at unbiased truth when the subject of study is a different culture. This becomes apparent when a young and emerging culture meets an old and temporarily declining culture. The new culture which has recently become self-conscious and has been awakened to the value and glory of its achievements is found to be quite reasonably assertive. The old culture on the other hand which has been long tested and tried is found to be understandably confident about the stability and value of it. This and the currently declining state of it make the members of the old culture both indolent and largely incompetent to become outspoken, let alone assertive even when the need is there.

When later during the early phase of culture-study the researchers belonging to the new culture find themselves in the compulsive presence of an old and great culture, it becomes very difficult to remain emotionally uninvolved. But cooperation and intellectual or academic help from an adequate number of well informed and enthusiastic scholars, belonging to the old culture, are not available to compensate for the lack of detachment or of emotional calmness so necessary for objective study.

The members of the new culture, who have first hand knowledge of the great achievements of their own and are virtually ignorant of the other culture or cultures, cannot naturally help developing commitment to the norms of understanding and standards of evaluation including theoretical evaluation, available in their own culture. Commitment to such norms and standard become so ingrained in the habit of thinking and action of those people that a distinctive ethos and a frame of mind is created. It is no wonder that the people sharing this frame of mind would find good reasons to assess their culture the way they do and conclude that it is superior to other contesting cultures. Thus supporting and being supported by each other, the standard of evaluation and the judgement of assessment including a distinctive outlook go on founding themselves ever more firmly. A time comes

when alternative outlook does not even seem to merit consideration or the possibility of such alternative is not even seriously entertained. This may be how what might have been an honest and objective judgement regarding achievements of one's country turns out to be responses of nationalist chauvinism which not only makes the respective people blind to the truths about other cultures but also make them distort those truths.

The picture seems to be fairly true about the conditions under which the West initiated the study of the East in general and of India in particular. Cultural chauvinism of the West found the obligation to prove the superiority of Western culture quite oppressive in the compulsive presence of such great culture as the Vaidika culture. This is true both for those who would study India including India's theoretical culture and those who would preach Christianity. The missionaries of a proselytizing religion became missionaries of civilization. Torn between their allegiance to a religion which was both in odd relation to the new ethos getting established ever more firmly and was fast losing ground in scientific Europe on the one hand and awareness of the emerging scientific culture which is secular and positivistic, these missionaries turned to the East where they had no fear of resistance from science. Only resistance they apprehended was to come from 'dark' religion. It is in some such conditions that the West began to study India—major areas of study had been the Veda and the religious and historical aspects of the old culture which was soon to be called Hindu or Indian.

Indological studies produced the expected results. Even when these were not string of untruths deliberately produced, for there had been quite a number of well-intentioned and honest scholars, assessment made about the truths discovered and implications drawn therefrom were hardly more than superficial. This could not perhaps be helped because these scholars were already handicapped by prior commitment to certain standards of judgement and a frame of mind, besides being emotionally predisposed in a certain direction. Their Indian counterparts, overtaken by diminishing confidence and indolence, preferred to by pass their obligation to offer informed, corrective and critical response (appreciation) by feigning an attitude of studied indifference or uttering seemingly matching but actually unconvincing eulogies extolling India. Exceptions had been there on this side also; but their number and impact had been insignificant.

This situation—of undermining Indian culture by misrepresenting it on the one hand and eulogising India without any deep understanding of its culture on the other—might continue for a longer time, without either party gaining much ground over the other or being able to do much damage to the other, but for the following fact. First political and then, economical sub-

jugation of India under the long spell of British rule resulted in the loss of cultural independence. We lost 'Swaraj in ideas'.

The hegemonic texts and studies on India or containing views about India which were produced by such Englishmen as James Mill who defeated the father of Indology, Sir William Jones, or Hegel or Marx combined to establish certain way of looking at India. Indian thought is essentially dream-like and Indian civilization is inherently irrational.¹¹ Till 1961 India failed to produce or complete studies which could counter the standard occidental view which placed India much lower in 'a global scale of civilizations and cultures with the West at its apex'. If the views were expressed just in such uncompromising language then an offended nationalist chauvinism would have more arrogantly responded to them. But the views much to the same effect were put more cleverly and sometimes with the backing of research works of acknowledged intellectual value. On the other hand, in the nineteenth and early twentieth-century Indians failed to produce confident but alternative hegemonic account. All these explain how the people of India were outwitted and how they were made to concede to the West a position of superiority. Since works like those by Said (1978) and Inden (1990) have been published, one can hope that an increasing number of Indians will soon come to believe honestly and say openly, after independent study and research, that it had been sheer bias on the part of the Europeans to think, even before Indological studies really begun, that dreaming irrationality was the distinctive trait of Indian thought, that Indian civilization was essentially irrational. But let us first complete the story of India's conversion to this wrong faith.

IV

The world at large including India was made to believe that the Indian culture was spiritual. We were outwitted to think that it was a great compliment made in right earnest and on the basis of correct appreciation of the spirit of Indian culture. We did not fully realize that it was another way of denying to India her claim to being civilized in the sense of having scientific, and rational culture. The missionaries thought, and they said so, that they were spreading civilization among uncivilized people when they were preaching Christianity. But this story of uncivilised India in its crude form could not gain currency among the Indians even in late eighteenth century. For at least the educated Indians at that time had the courage to think and speak otherwise; besides it was still a part of living memory how the Vaidika culture successfully absorbed the impact of rival religions. But these very Indians

were beaten, it seems, in their own ground when India was praised. The real import of the compliment that India was a great spiritual culture was negative: India was not a scientific culture. This came to mean soon that it was not a rational culture. The picture of India that was thus spread by the Westerners, particularly the British, German and French Indologists, and those Indians who followed them blindly without noticing the constraints put on these foreigners by the respective ethos and chauvinism, was that Indian culture was dogmatic, religious, mystical, non-scientific and irrational. By contrast the European culture was critical and scientific. Thus we find that the Indians in the late eighteenth and nineteenth century were conceding to Europe, while defending Indian spiritualism, a place of superiority in the field of theoretical rational culture and science. They thought that intellectual rational growth of India could be ensured if only English education system could replace the indigenous system of education and Western science were allowed to replace Sanskritist studies including Indian philosophy. It was said '... the Sanskrit system of education would be best calculated to keep this country in darkness'; 'improvement of native population' needed the institution and promotion of 'a more liberal and enlightened system of instruction embracing Mathematics, Natural Philosophy, Chemistry, Anatomy with other useful sciences.'¹⁸

Only gradually it became clear that we could not import Western science (even as a course of study) without at the same time importing the associated philosophy of science which happened to be materialism. A problem of reconciling Indian spiritualism with Western science was thus created as a result of the advent of the West. At that time solution or reconciliation was envisaged by modernizing Hinduism in the light of the scientific rationality of the West. The circle was complete, West's point was vindicated. Indians conceded that indigenous system of instruction, sastras and 'dark' religion had to be revised in the light of West's achievements and contributions in the field of culture. Anyway, by the time Rammohun Roy was in the scene the transformation of Indian mind was almost complete. Only in course of time contradiction and inconsistency in Rammohun and consequent attempt at honourable reconciliation between two cultures degenerated into passive acceptance of the superiority of the West. Rammohun who declared that the Sanskrit system of education was an instrument of stalling progress of civilization was found at the same time to be establishing Vedanta college; he also undertook to study seriously the Upanishads and other Sanskrit literature. Miss Collet thought it proper to suggest that the contradiction in all these would seem apparent if we view Rammohun as combating 'both the conservative Christian who advocated indiscriminate

rejection and the conservative Hindu who advocated the indiscriminate retention of Vedāntic teaching'.¹⁴ But what is this indiscriminate retention? Retention of otherwise sound principles along with the unacceptable features. But how a thought of discriminating these features were suggested and what standard was used for that purpose? If we are to judge by the result then not only idolatry but most of the practices of the Hindu society met with disapproval. If Rammohun undertook to study the literature only with the purpose of purifying our religion from a rationalist scientific motive then that would be welcome to and consonant with the spirit of Max Muller, the great Christian student of Indian religion. Whatever that may be the reform of religion took a distinctive direction towards making it acceptable to minds dominated by the norms of rationality of the scientific West. The religion of the Brahmas, a new religion became more intellectual and almost solely a matter of ideas. Whether or not practices are essential part of religion as such they are conceived to be so of Vaidika dharma. Be that as it may, my major points are two. Even when resisting attempts to deride or denigrate our culture we were becoming more and more critical of our own system of education, literature and religion. And in doing this we were accepting superiority of the West both in science and in other culture areas also. This would not have been possible if we simply resolved to learn Western science and were never overtaken by Western mentality. In the field of (material) science we gave the West a simple walk over. In the field of religion we initiated a movement of reform and modernization which betrayed our adopting tacitly a standard of acceptability or norm of rationality which was largely Western. The Orient and Orientalism which were established in India had originally been the discovery of the West. In contrast to this imagined Orient the West realized or sharpened its own identity. But because the nature of the identity of the West remained unclear at the time, we did not endeavour to discover our true identity. West's India became our own India.

A few characteristics of the cultural situation we have been describing as metamorphosis of the Western mind and advent of the West in India may be noted. The exact nature and positive content of scientific culture or rationality was yet to be clear. It was mainly conceived negatively as a liberating force which promised to free us from the dominance of 'dark religion'. Besides comparing and contrasting Western science with the then religion, it was contrasted with the then Philosophical systems. But though in India there was no sharp distinction between science and philosophy, it was already emerging clearly in Europe. Hence it was believed that there

was no science in India on which the impact of Western science should be carefully studied.

This picture of India created a mentality in which is deeply ingrained a sense of futility in respect of serious research into India's past for recovering scientific achievements and, more than that, insights which could be useful and relevant even today. On the other hand there developed mistrust and skepticism towards the possibility of Indian science. We were made to believe that in India there could develop only spiritual studies and practices but not science or scientific studies.

The picture of the world the West drew and popularized created a division in the global theoretical culture: the scientific West and the religious East. Subsequently the theoretical culture had to be further fragmented, with the degree of sharpness unknown hitherto, into scientific and humanistic. This division is still there in full force in the West and hence in India even nearly hundred years after Russell lamented over the fact that Mathematics and Philosophy were taught in different departments in a university. This division was made not for the purpose of greater emphasis on or promotion of humanities, nor it had anything to do with the humanism of the age of renaissance or enlightenment. The fact was that the science the West claimed credit for happened to be primarily physical science. Materialism proved to be the most suitable form of philosophy for the practice of this science. Remarkable advance was also made in the field of natural and physical science. Thus physical nature as distinct from man and his concerns and behaviour came to be distinguished as subject matter of rigorous theoretical study.

Having lived long under oppressive influence of religion the scientific West responded with vengeance and convincingly established, at least wherever it could set up colonies, that modern age was scientific age and that rationality meant scientific rationality. This mentality (no less than availability of capital, need for industrialization, etc.) had been responsible for the growth and development of science in the West and of its sense of superiority on that account. On the other hand the picture of India the West drew and popularized through the institutions they established and courses of education they introduced in India with enthusiastic support from some Indian educationists became one of the greatest important factors for the non-development of science in India. Against this background it seems that the need of the day is to undertake research to rediscover the cultural identity of India; its picture as a total culture and not just a spiritual or religious one. Good works have been and are being done separately to

combat Euro-centric approach to culture study and studies in Indian history, science and philosophy. Some integration seems necessary and desirable.

I have endeavoured so far to argue that the need for undertaking research projects to rediscover India's cultural identity would not have arisen but for the metamorphosis of mind India suffered under the impact of the advent of the West. I shall presently speak a little more about why the West could not help initiating such transformation of the Indian mind and under what condition the West came to convince itself to be *the* scientific culture. That the West did not give India or any Asian country her share of credit for contributing to the world scientific culture is well known. Nor is the West prepared, it seems, to admit that in respect of modern science she has even inherited anything of importance from the Greco-Roman culture. I have also tried to show that the metamorphosed mind of India or the West which caused this distortion, is responsible not only for the belief which caused an attitude of skepticism and sense of inferiority among the modern Indians but also for the belief that India is only a spiritual or religious culture. There are Indian scholars like A. Rahman who would make the West responsible for spreading the first belief which is false. While accepting Rahman's authority on this point some Indian scholars would make the conservative Indians or Asians responsible for spreading the second kind of belief in 'defence' of their cultural stagnation or in the interest of projecting 'the irrational religious-mystical trends of the past as representing the quintessence of Asian culture'.¹⁵ These scholars I am afraid cannot easily explain how the West succeeded in making the Indian believe that science was the monopoly of the West or that the Indian culture was non-scientific and irrational. I am inclined to think that the Indians derived from the same source both the beliefs that the West is the scientific culture and Asia or India is simply a religious culture. For one thing the Indians did not have to disown science to claim credit for religion. Science-religion dichotomy or antagonism between science and religion, that religion is anti-science and represents the force of ignorance and superstition, are all imported ideas—imported by scholars who can ignore the evidences of two devastating world wars and think that the hold of religion and weak scientific temper in India are responsible for greatest number and variety of social evils including casteism, communalism, and other forms of unfounded discriminations. Men like Joseph Needham and Professor Gopinath Bhattacharya have made more realistic assessment of the situation.¹⁶ Science worship is a thing of the past and it is wholly unjustified to accuse, in the manner of late Indira Gandhi, our scientists of leading a schizophrenic existence if they are found to bear an attitude of balanced esteem both to science and ethico-spiritual

tradition of their country.¹⁷ I have sought to argue that though generally ignored, the state of mind of its people—their beliefs and aspirations—is an important factor in the development, decay or even absence of science in a particular country or at a particular time. The value of all these in shaping our approach when we undertake projects of history of science is to impress upon all concerned that our history should not aim at discovering only facts or evidences of scientific achievements but also, and primarily, the Indian mind.

V

In view of what we have said so far it is fairly clear what task remains to be accomplished. Broadly and negatively speaking, we must correct the currently popular but false picture of cultural India and, if that cannot be done otherwise, we are also to correct the corresponding picture of the modern cultural West. Positively, and again broadly speaking, we are to rediscover the true cultural identity of ourselves. But some quite serious works have already been done or started in this direction. Do we aim at simply reaffirming all or most of what have already been said and written on the subject. Even if that might serve some purpose there are more urgent needs. One is to consolidate as far as practicable similar activities undertaken independently; and to convince ourselves thoroughly if there is in reality and not merely in words a distinctively Indian approach and attitude, orientation and point of view; and if there is what is its exact nature. In short what exactly is the Indian mind. For it is this mind that really accounts for the character and progress of a culture at any given time. The history that can largely ensure growth of a culture along certain line is the history of the emergence of the mind of the people and not merely the history which records facts. Science has been the single largest contributing factor in the metamorphosis of the mind which is modern West. It has indirectly helped in the metamorphosis of Indian mind which is still now dominant (probably because until recently most of us were not explicitly aware that it was the creation of the scientific West). Thus both for correcting whatever error there had been in the dominant picture of India and the West, study of cultural history and history of science is a must. And while our aim should be to rediscover the cultural identity of India distinguished by her own norm of rationality, we should be aware that the West has largely succeeded in universalising their own norm of rationality. We are over possessed by a norm of rationality which is essentially scientific and a conception of evi-

dence which is mainly historical. This history itself is dominated by ideals of scientific objectivity. In spite of our long acquaintance with Western science, the exact nature of scientific rationality remained till recently and, among many even today, obscure. Therefore whereas we are to study Indian science we cannot begin by simply accepting the framework dominated by certain notion of scientific rationality and historical evidence which are rooted in an alien culture. So we need to further clarify the Western notions of rationality and evidence; and at the same time we should search for if and what alternative notion of rationality and evidence India developed independently. There is nothing wrong even in suggesting new standard of rationality and evidence; and undertaking historical study of a different sort. The relevance of conventional history to historical study of science has been powerfully challenged by Kuhn around 1960—a time when 'a crisis of rationality' emerged in the West. Some philosophers started worrying whether reason has much of a role in the production or assessment of scientific truth. It is perhaps a social product with no claim to validity by abstract rational standard.¹⁸

Once we convince ourselves that history need not be the one which conforms to the characteristic Western notion of it we begin to see in the new light the popular belief that India did not develop history; that history is perhaps India's greatest weak point. So far as science is concerned a more guarded statement is made: Indian culture is essentially religious or spiritualistic. It is implied thereby that this culture is not scientific. But how we came to believe that such implication holds? There is nothing in the concept of science that science has to be physical science. We now-a-days speak freely about life science. Why cannot there be spiritual science also? This line of argument should not be stretched so far as to abandon the last vestige of rigour and clarity which the concept of science has acquired though at the cost of narrowing down its field. But there is more pertinent question, if India did develop science (and also had been always in the past a land of great religion—even if great next to Christianity!) how did the West and India remained distinguished as scientific and spiritualistic culture respectively?

In principle there is no need to think either that every culture must be scientific or no culture can be spiritualistic. But so far as India is concerned, it is a total and also a living culture. What was wrong with the Indological studies and West's historical studies is that in them the scientific and intellectual India was pictured as dead and past or as ever non-existent. India has been or is a partial culture, only a religious and spiritual culture. But if we knew that materialism was not the only possible philosophy of

science or that there was no core of precise meaning common to various usages of the words 'mechanics', and 'mechanical', then we would not be convinced that Indian culture, because it was spiritual, was not scientific or rational.¹⁹ Instead of pursuing in this vein of simplistic and popular exposition let us address ourselves to more substantive task. So far as this paper is concerned I would like to suggest that India has her own vision of history; it is enshrined not only in the *itihāsa*-s (so well defined a subject) but also in the sense of the past (as well as vision of future) so vividly portrayed in the style of thinking, speaking and writings of classical India. I also believe that India has her own conception of rationality which matches quite well her notion of history in the sense of *itihāsa*.

I have been trying to say that if things are seen in their right perspectives then science and history of science are closely related; our study of them may combine into one broad and single project of a study of theoretical rationality. We may undertake to study the components of theoretical rationality of a certain culture independently and in isolation or with reference to some other culture. If science is viewed merely as a certain finite body of statements or history is viewed as mere repository of anecdotes and chronology then one may not expect much from the study of history of science either by way of revolutionizing our conception of science and or creating crisis of rationality, as it did in the West around 1960s or by way of creating the conviction that India is and always has been a scientific culture with her own conception of rationality. Such a conviction can go a long way to laying strong foundation for the growth of original and indigenous science.

There had been reasons why in the post-renaissance Europe natural or physical science was viewed as man's highest intellectual achievement, why science alone came to be viewed as knowledge, or why science could effect metamorphosis of the Western mind. Let me tell in brief that part of the story to make my account complete. Renaissance witnessed both the movement for the revival of the past and emphasis on progress. The picture of the modern man (human individual exemplifying the spirit of modernity) has been that of a ceaseless explorer and discoverer of new territories of knowledge, in spite of all his reverence for the past with its heroes and heroic achievements. Europe rediscovered the excellence which Greco-Roman culture reached in the fields of law, literature, philosophy and even medicine; all of these were included as courses of study in humanities in the system of liberal education. An emerging self-conscious modern Europe so eager to assert its unique theoretical cultural identity could not be happy to find herself under the burden of indebtedness to Greco-Roman culture. It was hard to deny that,

for her humanistic culture Europe was indebted to old Greece and Rome. Europe found the prospect of satisfying her pride of and craving for self-identity as the originator of physical and natural science. Thus foundation was laid of a theoretical culture in which science became the measure of everything and Europe assigned to itself a place at the top of the scale of 'civilized' countries and nations. But Greece had her own excursion into science and if Socrates (there must have been others as well) did not consciously play the important role he did to stop the progress along that line and give strong boost to non-scientific humane culture dominated by metaphysics, morals and politics, then Europe would have found herself in alternative indebtedness to Greece. But the more important point to note is that alternative measures of theoretical culture came to be operative in Hellenistic and European culture. In the post-renaissance modern West science is in the centre of the theoretical culture as a whole. It not only determined the form, style and approach in other areas of theoretical culture, it often supplied problematic and themes to other theoretical disciplines like philosophy and history. Even art and literature came to be determined in respect of form, content and even motivation by what was going on at the time in the field of science or sciences. To give just one example from our times, new developments in physics undermined our belief in the objectivity and universality of causality; it was made apparent that there was subjective element in scientific findings. As a result 'The "world out there" lost its putative solidity; and art—painting and sculpture—began to lose the basic, structural certainty which arose out of fixed view point of Renaissance perspective. Hence the dissolution of forms of the cubists and increased subjectivity of the surrealists; the way had been prepared by the momentary and essentially fluid evocations of the impressionists.'²⁰

In the science dominated theoretical culture of the modern West the conception of philosophy itself was changed and themes and concerns in such branches of philosophy as logic and epistemology came to be determined by the needs of science. I have no scope here to discuss these important points even in brief. Some indications should, however, be given about the point I want to make. The domination of science in the area of theoretical culture resulted in the conviction that strictly speaking, science is the whole of human knowledge. So whether it is logic or history, epistemology or linguistics, or any other branch of study, its claim to be considered as a body of knowledge was to be tested in terms of its compatibility with or utility for science. Logic is what brings rigour to science and defines our notion of scientific rigour. Epistemology must be primarily a theory of

scientific knowledge; its basic concern is how science could be shown to be possible. Philosophy and history have to be scientific even religion and morality should be so. Those branches of science which fell short of the standard of rigour and perfection of the advanced sciences of physics, astronomy or mathematics were given low status of soft science. These were also science of low priority till recently.

Thus the conception of the role of philosophy did not remain the same always and everywhere. In the West the image of a philosopher has changed. 'Philosophers have become technicians, they had abandoned the role of sage'.²¹ Stephen Hawking lamented over the 'come down from the great tradition of Philosophy from Aristotle to Kant'.²² Aim of theoretical disciplines continued to be described as knowledge or theoretical understanding. But notion of knowledge did not remain the same. Paradigm of knowledge changed. Russell urged in 1914 that the philosophers should give an account of the 'world of Science'. Popper wrote in 1945 '... in science there is no "knowledge" in the sense in which Plato and Aristotle understood the word.' Ryle in 1949 wrote that the task of Philosophy is 'not to increase what we know ... but to rectify the logical geography of the knowledge we already possess.'

Science so viewed, is not just a descriptive term, it is a value-loaded term. It is no longer a certain body of statements but is the arbitrar of what to accept as knowledge; it is or it came to dictate norm of understanding and standard of rationality. Science of the modern West cannot be studied apart from the scientific culture it initiated there. And the history of a culture cannot be grasped just in terms of cold chronology, or actual occurrence of events and their faithful objective account which makes no serious reference, in case of Europe, to Europe's desire to see itself as a distinctive culture and not just as the bearer of the legacy of an alien culture. We need a history which the people of a culture themselves wrote not in the form of books and records but in terms of hopes, aspirations, attachments, aversions and the like which combined to form an image of that people. This image may not be ever fully realised, but still in an important sense a culture is the projection of the image the people of it have and bear about themselves. This image partly determines both theoretical and practical value. We need a history of science of a country which will aim at grasping if the country has a scientific culture, if it imagines itself as a culture in which science will dictate standard of theoretical evaluation. A country has a scientific culture to the extent it bears its image as scientific culture and not just to the extent it has at any given time necessary equipments and resources in its store or

actual achievements to its credit. Such study whether or not it is history in the conventional sense of the term is needed to discover how a culture looks to those who identify themselves with it and then analyse the nature and components of that idea of that culture. The culture of a people is the self projection of the latter—an image which is ever emerging, now progressing, now receding but very rarely getting completely destroyed. How science figures in the self image of India as it is and not as it had been imagined by the West and sold to the Indians, is what I hope to learn from a project of history of Indian science.

VI

In more concrete terms there are some general and special risks involved in undertaking to study the history of Indian science and philosophy (I shall confine myself to these two only), if it is to serve the two related needs about the urgency of which I have been speaking now for years. Though these needs are now being felt by all who are concerned yet the needs are not always clearly articulated. If history of Indian science and philosophy means an account of what India achieved in these fields in the past, updated and corrected from time to time in the light of fresh search and new discoveries of archaeological and other evidences acceptable to the historians, then it may be said with fairness that considerable work has been done and search for new evidence has not stopped. But such studies have been undertaken for their own sake or for the narrow end of academic history or for such ulterior motive as to create in the minds of the Indians a sense of inferiority. Besides there is no exact ratio between the 'quantum' of theoretical attainments and the quantum of observable achievements which counts as evidence of the former. Whereas books and paper documents are far more easily perishable, telling evidences of durable forms like architectural creations, machineries like power plants etc. presuppose development of technology. But technological advance need not be and is not proportional to the development in theory. This is true from the other side also. Separation of logic from practice, theory from technology is not the sole or the most important factor which causes decline of science in a culture. In fact a certain amount of distance between the two may often prove beneficial for the healthy development of both. We are to undertake a different approach in the study of history of India. For our need is different. We need to rediscover our true cultural identity which is not exhausted by the archival materials or archaeological findings alone. We need to reaffirm the identity of India as a total culture not primarily to convince the people of the West

but to convince ourselves and our own people. Why this is necessary to secure the growth of indigenous science (the second related need) and why the same cannot be secured by accusing our scientists of schizophrenic existence, I have explained above.

There are some general risks involved in the historical study of culture areas or theoretical disciplines. Studying a subject which has its own history of growth can be completed by many scholars. Nothing of importance is likely to emerge if the scholars do not have unity of approach which in its turn requires a fairly deep consensus as to the nature of the subject which is being studied. If what is to count as that subject or the evidence for the existence of that subject somewhat change from time to time and place to place, then we shall be talking indeed very vaguely if we do not work within considerably short range of space and time. In case of India the risk is still greater. For whereas we do not want Indological study by the Westerners or Westology by Indians (but history of Indian science and philosophy as the Indians themselves conceived them), we are trained in and conditioned by the ways of the Westerners. Where the need is so great to view things in our own ways, no amount of time and caution should be considered too great to avoid the risk of importing problems which are alien to our culture but very much constitutive of the approach which shaped the nature and conception of the subject for those whose language and concepts we shall be using in our study. I shall illustrate my points with examples of some of these problems and end by enunciating certain principles which may be followed to preserve the Indian nature of the study of the history of Indian science and philosophy. There are some problems about the notions of time, causality and periodization, which are pertinent to any historical undertaking. I shall only say a few words about the first two.

It is believed that conception of time one has affects one's views as to the possibility and nature of the studies like science and history. At a deeper level the reason is to be sought in the bearing which the alternative notions of time has on the other two conceptions of causality and progress. Conception of progress which became constitutive of the representative modern man personifying the spirit of modern Europe is foreign equally to Christian West and Pagan India. We should carefully distinguish between conceptions of linear time and linear progress. Rejection of the notion of linear progress does not necessarily entail a conception of cyclic time. We cannot go into this very important and interesting distinction in detail. Let me speak with usual vagueness in terms of linear and cyclic conceptions of time. One major source of opposition to non-linear conception of time is that it renders

impossible theoretical explanation. For the model of explanation as has been dictated by Western science is best described as mechanistic causal explanation. But causal relation involves temporal succession the denial in principle of which is entailed by cyclic conception of time. Indian view point is sometimes defended by saying that the Indians had conceived each cycle of time to be so large that for all practical purposes it can be taken as linear at any given moment of time. Analogy is readily available. Standing on any point on the surface of the earth we can conceive the surface to be circular but in terms of actual experience it is as flat as the palm of one's outstretched hand. Anyway, at least the Nyāya realists believe that both conceptually and literally time can be stretched backwards infinitely. In future also it can be stretched indefinitely if not infinitely. Yet these realists entertain all those beliefs which are taken to be evidence of one's believing time to be non-linear. So far the Indian notion of theoretical rationality, since it is causal, is not different from the scientific rationality of the West. But whether due to the dominance of mechanics or anything else Western conception of causality is mechanistic in a sense in which it may be thought, with initial plausibility, to be different from the corresponding Indian conception. Again, according to the Western conception, science is a body of knowledge different in kind from the knowledge one may find in philosophy. The Westerners are as a matter of rule equivocalist so far as the expression knowledge is concerned. Sometimes it is said that science gives us factual knowledge whereas philosophy can give us only linguistic knowledge. In India we, the Naiyāyikas at least, are univocalist in this respect. I have argued this point elsewhere in detail.²³ So when we undertake to study the history of science and philosophy in India we should remember:

- (1) Our conceptions of philosophy, science and the relationship between the two are specifiably different from those of our Western counterparts. Only one such difference in terms of univocalism and equivocalism in respect of 'knowledge' has been noted above.
- (2) Anti-Psychologism is a dominant trend in the West so far as hard core scientific culture is concerned. This has shaped in important ways West's answer to the question what it is to give scientific explanation.
- (3) Belief in evolution at least in the sense of belief in linear progress and science as cumulative are still dominant trends in the West. I doubt whether they had ever been so in India.
- (4) What professor Gopinath Bhattacharya described as authoritarian-rationality is the dominant notion of rationality in Indian philosophy.²⁴ This is not so in Europe.

- (5) European philosophies have a certain unity consisting in their accepting science as paradigm of knowledge. Unity or difference among the Indian philosophies, as they are usually grouped, in terms of their relation to the Veda, does not have much scientific relevance or content.
- (6) India and the West have altogether different answers to offer to one central question of scientific methodology (of the West). How movement from sense to science is possible?²⁵

These and many more such points and principles are to be enunciated and clearly borne in mind if we are to succeed in discovering India's science and philosophy, and what is more, the total, including theoretical, culture which India has always been.

NOTES AND REFERENCES

1. This article is a revised version of the paper 'Projects on India's Theoretical Enterprises: Some Reflections' contributed to PHISPC Workshop held in Delhi from 7 to 10 November 1991. Invitation to contribute to the Workshop-cum-Consultation Meeting had some special significance for the author; for about a year or so before he started to collaborate and work in the Project: Foundations and Methodology of Theoretical Sciences in Indian Tradition (FAMTSIT). PHISPC appeared to be a related project of much wider scope. Success of such projects depends much on firm conceptual foundation. The Workshop under reference was organised to ensure this. What was learnt from other contributors of the Workshop has helped me in revising the earlier version. It was thought proper to change the original title, after the revision, to 'History of Science and Two Metamorphoses of Mind.'
2. Cf. Needham 1975, p. 220.
3. Cf. Rahman 1984, p. 22 and Chattopadhyaya 1986, p. 38.
4. P.C. Ray held such view; this was rightly ignored by Priyadarajan Ray, though he had been taken to task by Debiprasad Chattopadhyaya for that. I am afraid that their alternative religious faith or commitment to certain sort of atheism had determined the views of P.C. Ray and Chattopadhyaya. Objective study of the texts of Advaita Philosophy or the nature of conceptual framework needed for the development of science, as has been shown by men like Kant, say, does not warrant the sort of criticism to which Śaṅkara's Vedānta has been subjected by these scholars. See Mukhopadhyaya 1984, p. 243.
5. Cf. Dubarle 1971, p. 16.
6. Ibid., p. 16.
7. The History or the story of this gradual transformation is receiving only in recent times some serious attention in the wake of global concern over Euro-centrism. But to fully appreciate the effect of this transformation on non-regeneration of science in India, serious research in history of science is necessary. But as late as in 1969 and 1979 Joseph Needham could not help noting that the historians did not show as much interest in the

science and technology in non-European civilisations as the scientists, engineers and philosophers had shown towards history (of science). Even the first comprehensive history of European science was written by one who was not a professional historian. He for that matter did not write whatever he could and gave it the name of history. He was at least clearly aware that history of science was different from philosophy of science and that the latter should be based on the former. His three volumes of *History of Inductive Sciences*, etc. published in 1837 were followed by three parts *Philosophy of Science*. The historians of our days also have not generally shown great interest in science. Neither Professor S.N. Sen nor Professor Debiprasad Chattopadhyaya, who have written extensively on the subject, though from different point of views, are not historian by profession.

The need for and the nature of the task is fairly well known. History of science of the sort we need today can be written if only historians philosophers, scientists, and oriental scholars bred in traditional seminaries of learning collaborate. Fortunately PHISPC has the right perspective and hopefully adequate resources to ensure adoption and completion of such joint work. One minor point may however be noted. In their *A Concise History of Science in India*, Bose, Sen and Subbarayappa did not give Linguistics its due importance. Navjyoti Singh noted it in the paper he contributed to the volume Debiprasad Chattopadhyaya brought out in 1986. The place given to the subject in the preliminary plan of work of PHISPC seems to be far less adequate than what it should be, if we consider the vastness of the project and the fact that in Indian theoretical culture linguistics occupies a position which is comparable to the position geometry enjoyed in Greek thought (cf. Staal 1965). There is however ample time to redraw the work plan and give greater emphasis on linguistics. It may also be noted that the scholars working in the project FAMTSIT (Foundations and Methodology of Theoretical Sciences in Indian Tradition), another DST Project, have been invited on behalf of PHISPC to collaborate. And FAMTSIT includes the theme of Indian linguistics at par with such other themes as 'Design and Testing of Hardware for Optimal Algorithms with Suggestions for Application'. In fact six out of some fourteen schemes under FAMTSIT provide scope for comprehensive study of the phenomenon of language from the Indian perspective. But the approach there is foundational rather than historical.

8. Cf. Agassi 1967, p. 503.
9. Cf. Putnam 1975.
10. Cf. Said 1978, p. 1.
11. Cf. Inden 1990, pp. 44–8. Inden wrote in this very thorough study of the contributions of the Indologists, 'I am claiming that it is wrong to see Indian thought as essentially dreamlike and to view Indian civilisation as inherently irrational.'
12. It would be said if the author of the review, recently published in *Nature*, of Debiprasad Chattopadhyaya's book on the History of Indian Science, got from this book in 1990, the impression that India had been a dreaming and irrational country.
13. Cf. Ram Mohun 1823.
14. Quoted in Ghose, Ajit Kumar, 1973, p. 23.
15. Cf. Chattopadhyaya 1986, p. 45 fn. (b) *ibid.*, p. 46.
16. (a) Cf. Needham, Foreword in Chattopadhyaya, op. cit. (b) Bhattacharya, Gopinath, Lecture.
17. Cf. Inaugural address by Indira Gandhi in the 55th session of Indian Science Congress, quoted by Chattopadhyaya (1986). In her address delivered in January 1984 on the

occasion of the Bi-centenary of Asiatic Society, Calcutta. Indira Gandhi praised society's contribution towards 'rediscovery of our heritage and' restoration 'of self-respect'. She spoke of India's 'intellectual' and 'scientific' achievements which were revealed to Europe by the Society 'when we were enveloped in doubt and difficulty'.

18. Hacking 1983, p. 1.
19. Cf. Nagel 1979, p. 156.
20. Cf. Bantock in the 7th volume of the *New Pelican Guide to English Literature*.
21. G.H. Bantock, 'The Social and Intellectual Background', *Pelican Guide to English Literature*, vol. 7.
22. Cf. Hawking 1988/89, p. 185.
23. Cf. Mukhopadhyay 1984, pp. 242-3.
24. Cf. Copinath Bhattacharya 1989, p. 173.
25. Cf. Mukhopadhyay 1984, ch. 3.

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Some Aspects of the Navya-Nyāya Theory of Language

SIBAJIBAN BHATTACHARYYA

Concept of Language

Different concepts of language give rise to different problems and to different theories of language. I shall explain here only a few concepts of language. (1) Language may be defined as man-made sounds to communicate information or thoughts. The most common form of sounds is articulate speech. But this definition of language is wide enough to include drum-beating, or playing of any instrument, musical or non-musical, as in morse-code. Of these different forms of language, articulate speech is the most basic form, for all other forms logically depend on it. The different sounds of instruments have to be conventionally related to information which can be done only through articulate speech.¹ Morse-code, again, depends logically on the analysis of speech into letters of the alphabet. Although this conception of language is quite general still it does not include other forms of behaviour which may be regarded as language in a still more general sense. (2) In this very general conception of language, any behaviour, not necessarily speech-behaviour, which can communicate information or thoughts, may be called language. In this sense gestures and postures are regarded as forms of basic language. It has been argued that gestures are more basic form of language than speech. A person in a foreign country may use gestures to communicate to others that he is hungry or thirsty or whatever. Gestures have to be distinguished from postures which even animals can understand. Postures are natural responses common if not to all animals, at least to

higher animals. Postures constitute a very poor language, as not much information can be communicated through them. St. Augustine has asserted that gestures and other bodily behaviour constitute the natural language of man.² That is why a child learning his first language observes the behaviour including gestures of the elders.³

It may be argued that whether gestures constitute a very poor language. We cannot express all our thoughts or communicate all information by gestures. But this objection is hardly valid, because like all languages the gesture-languages must also be learnt. Gesture-languages have developed as sign-languages which is learnt like any other language.

It has been argued by Bennett that bees do not have any language even though they communicate through dancing. His argument is that the dancing of the bees is instinctive and does not require to be learned. An essential feature of all languages is that there must be some conventions for the use of languages, and these conventions have got to be learned. If there is any form of bodily behaviour which communicates information but which does not have to be learned then it can not be regarded as a language.

(3) The two conceptions of language explained above do not include written language. Sometimes it has been argued that written sentences, specially written atomic sentences, are pictures of reality.⁴ But this theory overlooks a fundamental distinction between pictures and written language. A picture is related directly to the object of which it is a picture. Written language, even hieroglyphic, is not directly related to the object but to spoken words. Thus spoken language is logically prior to written language.

Thus Derrida's theory that written language is prior to spoken language is hard to justify. Even though written language expands the scope of spoken language in many directions, still the possibility of written language is dependent upon spoken language.

It is usual to distinguish between a natural language and artificial language. The distinction, however, is determined by what we mean by 'natural language' and 'artificial language'. We have already noted that according to St. Augustine bodily behaviour is 'the natural language of man'. If we accept this sense then spoken language will be non-natural language which if interpreted to mean artificial language, can be learnt by a child only through the natural language which he naturally knows. In this sense a natural language does not require to be learnt. But we also have Bennett's theory that any pattern of behaviour even when it succeeds in communicating information cannot be called a language if it is instinctive. In this sense a natural language will be a language of ordinary people used for all purposes. An artificial language will be a language invented by a group of men for a

specific purpose. It is usual now to distinguish between object language and metalanguage. An object language, like formalized arithmetic, is constructed by means of syntax and semantics in the metalanguage. This metalanguage is a natural language, supplemented by additional symbols, if need be. This metalanguage may, in its turn, be formalized by means of a meta-metalanguage which has to be a natural language. The point is that to construct an artificial language syntactical and semantical rules have to be stated eventually in a natural language as the artificial language is yet to be constructed. So in what follows we shall be concerned mainly with natural language.

Navya-Nyāya Theory of Language

Language is articulate speech. Sign-languages like showing two fingers to mean two and other gestures to mean that one is hungry, thirsty, etc. are languages only in a derivative sense just as written language. The Navya-Nyāya theory is that spoken language is language in the primary sense, whereas gestures and written language are languages only in a derived sense, for the gestures and the written signs remind one of the spoken words which would have been used to convey the same sense. It is only by 'suggesting' spoken words that these become a 'language'.⁵ The commentators of Viśvanātha make a distinction between the so-called gesture-language and written language by describing the former as language of a different kind (*vijātīya*) and the latter as of the same kind as the spoken language, by contrast, *sajātīya*. But even though gesture-language and written languages are thus different from each other in kind, still both of them differ from spoken language. They are called 'language' in the wider sense because gestures and written characters 'suggest' (*bodhaka*, *saṃketita*) spoken words which alone constitute language proper.

This Navya-Nyāya theory is based on the presupposition that written language is parasitic on spoken language, even though writing makes possible long and complicated constructions which would have been impossible without writing. Even admitting the fact that the art of writing does not merely gives permanence to speech and can be repeatedly observed, and also makes possible the development of language in newer directions, the fact remains that written language would have been impossible without spoken language. Thus spoken language is logically prior to written language. In their theory of meaning, Navya-Nyāya philosophers, therefore, regard spoken language alone as primarily significant and written language is taken as derivatively significant in so far as it suggests the spoken words.

It is only through spoken words suggested by the written words that they become instruments of communication.

About gesture-language, too, Navya-Nyāya philosophers hold the same theory of the primacy of spoken language. Here this primacy is not apparent; for, apparently, gesture-language precedes articulate speech in the process of evolution. Animals use bodily signs to communicate with each other without sounds. Yet it is a fact that articulate speech is different in kind from gestures which can be used to communicate only the barest information. Emergence of articulate speech marks a total break in the process of evolution. Many Western philosophers have even identified rationality of man with articulate speech which, then, is the differentia of man from other coordinate species. (Of course, Navya-Nyāya does not contain any ideas of biological evolution). Moreover, it is not clear if two deaf and mute persons can communicate by means of gesture language, for none can be reminded of the spoken words 'suggested' by the other's gestures, as none of the two can possibly know any spoken words.

Sanskrit as the Object-language

All systems of Indian philosophy offer a theory of only Sanskrit language and a theory of meaning of words and sentences of Sanskrit. It is necessary to note some special features of this language. One feature of Sanskrit as a language is that it is a *frozen* language; only as a frozen language it serves as the object-language in the Navya-Nyāya theory as also in Indian theories of meaning generally. Sanskrit, therefore, has a very rigorous grammar starting with alphabets classified into vowels and consonants, rules of formation of words from basic elements, rules of formation of sentences, and so on. Pāṇini's grammar with its rigorous definitions as explicitly stated rules of abbreviation, and rules with an enumeration which uniquely determines their order, with various devices for determining the scope of the rules and the order of their precedence, stand out as one of the best examples of the science of grammar. Still Sanskrit differs from a rigorously constructed artificial language as we have now, in so far as it allows ambiguous words, figures of speech and some freedom to analyze a given expression in different ways. A complex expression, therefore, is, in general, not uniquely analyzable even in the most technical language of Navya-Nyāya.

Dealing only with Sanskrit as the language of study gives rise to the problem of explaining the possibility of regional languages, and languages other than Sanskrit. An extreme theory, supported by Gadādhara, is to treat all expressions of regional languages as really devoid of meaning but used

in practice as significant only by mistake. Expressions of regional languages create only an illusion of sense.

This extreme theory has not been accepted by many Navya-Nyāya philosophers. Annambhaṭṭa, for example, in his commentary *Uddyotana* on Kaiyaṭa's *Pradīpa* gives an argument of some Navya-Nyāya philosophers against the theory supported by Gadādhara.⁶ We now explain this argument:

Like words in Sanskrit, words of regional languages, too, have meaning. For, there is no way of determining whether Sanskrit words have primary meaning and regional languages have only derivative meaning or conversely. The determinant here cannot be equiformity of words in all countries, for the meaning of 'equiformity' is vague and unclear. It may mean one of three different things:

(i) 'equiformity' may mean that Sanskrit words are used in all countries;

(ii) 'equiformity' may mean that words which are used in a particular region have a recognizably identical pattern;

(iii) 'equiformity' may mean absence of usage of regional languages. Now sense (i) cannot be accepted because in some foreign lands (*kvacin mlecchadeśe*) there is no trace of Sanskrit (*Samśkr̥ta-gandhabhāvāt*). Sense (ii) cannot be accepted because equiformity in this sense is common to all languages. Sense (iii) also cannot be accepted because it violates what has been stated in the *Bhāṣya* which in many places emphasizes use of different non-standard words among people. Even the way the elite speak cannot be the determinant, for this is common to all languages. According to these philosophers who oppose the theory which Gadādhara supports, God created the world of objects and also their names at the same time. It cannot be said that God created only Sanskrit language and no others. When God created the Ionians, He created their language also at the same time. It cannot be said that even those languages were originally Sanskrit, from which they evolved.

The attempt of the modern comparative philologists to postulate and construct a Proto-Aryan language from which all Indo-European languages have evolved according to rules of phonology, philology and grammar tends to support the theory that originally God created only one language, be it Sanskrit or some other language from which all other languages have evolved. The consequence of this theory of the origin of languages for the theory of meanings, according to Gadādhara, is that the exclusive concern of the theory of meaning should be with the original language as the object-language. Now this is a further theory which need not be accepted even if one accepts the theory of evolution of different languages from one language.

Thus the arguments given above of those who propound the theory which Gadādhara rejects are invalid, because like Gadādhara they assume the debatable theory of the logical connection between the mother language and the theory of meaning. Even if it be admitted that the regional languages in North-India have evolved from Sanskrit, it does not follow that words and sentences in them do not need to be explained and that no theory of meaning over and above the theory of meaning of Sanskrit is needed. This is the point which Jagadīśa and other Navya-Nyāya philosophers have made. According to these philosophers, there is a possibility of developing different theories of meaning for different regional languages; only they are not interested in developing such theories. They are concerned only with Sanskrit as the object-language.

Divine Origin of Language

Indian philosophers of the Nyāya school all agree that Sanskrit is a divine language, created by God. God as the creator of the universe is also the creator of all languages including Sanskrit. This is the point emphasized by the views explained by Annambhaṭṭa. One reason for holding this theory seems to be that language is developed naturally and not by convention. This theory of divine origin of languages, specially, of Sanskrit, which is the object-language of all theories of meaning in Indian philosophy, has a far-reaching consequence for such theories. To create a language is to endow expressions of that language, after they have been created, with meanings. God creates both the world of objects and also the language with which to talk about it. But this talking about the world of objects is impossible unless there is a relation of meaning between language and reality. According to Navya-Nyāya this relation between language and reality is God's will. That is, God did not merely create the objects and the sounds, but also instituted a relation of meaning between the sounds and the objects. Because of this relation sounds become expressions of a language. Spoken words as physical realities are merely a kind of sounds; they become language only when they are endowed with meaning.

The theory that meaning as a relation between an expression and an object, simple or complex, is the will of God who is also omniscient and truthful, has the consequence that no basic words can be empty, i.e., devoid of meaning (reference). Thus this theory gets rid of the problem of empty terms, as Frege, for example, does by constructing an artificial language and arbitrarily assigning the null object as the referent of all so-called empty terms which therefore no longer remain empty, but have the same reference.

But this device of Frege is artificial and there are Western philosophers who do not accept this way out of the problem posed by the existence of empty terms in a language. There is, however, a mere fundamental problem in any theory of meaning which the Navya-Nyāya philosophers try to solve in their own way by their theory that meaning is divine will.

Now although articulate speech is a natural development of a power in man, by which he is distinguished from other animals, still in later stages of development, languages are constructed, of course, by using natural languages—i.e. languages which have arisen and developed naturally. In such artificial languages, if used for communication, the relation of meaning between expressions of such languages and elements in the ontology is purely conventional, i.e. creations of the will of those who construct those languages. Later Navya-Nyāya philosophers take note of this phenomenon of creating technical (*pāribhāṣika*) terms and hold that the relation of meaning is conventional in the sense that it is created by the will of the persons concerned. From this they generalize to the case of even natural languages like Sanskrit and hold that the meaning relation is the creation of the will of man. But this amalgamation of natural languages into man-made languages raises various difficulties. For example, no artificial language can be created in a vacuum; such construction presupposes the prior existence of another language. The theory that natural languages could develop by human convention faces the difficulty of explaining how such conventions could ever be made in the absence of any language whatsoever. The two problems of origin of a language and constructing a theory of the nature of meaning for that language, though in all appearance fundamentally different, are yet essentially connected. For a language cannot originate without meaning objects; the nature of the origin of *language* determines the nature of the relation of meaning within that language. If the language is man-made, then meaning is also man-made for that language; if it is not man-made, then meaning is not man-made.

Theories of Language Learning and Theories of Meaning

Just as theories of the origin of language determine some fundamental aspects of theories of meaning, so also are theories of language learning and theories of meaning closely connected. Recently many philosophers like Davidson have argued against philosophical theories of meaning prescribing rules of language learning which must be empirically ascertained and not *a priori* prescribed. Yet it is a fact that different theories of meaning do determine at least some aspects of theories of language learning. For example, those philosophers who advocate that it is the sentence which is

the unit of meaning, and not the words, usually reject the lexicons as sources of word-meaning on the ground that in Sanskrit lexicons meanings of isolated words are given and not as they occur in sentences. The Mīmāṃsakas hold that meanings of words can be learned only from their use in sentences by persons who already know the language (*vrddha-vyavahāra*). The Nāiyāyikas, on the other hand, advocate the theory that isolated words are the units of meaning and hence accept grammar, lexicon, statement of authoritative persons, usage, and linguistic contexts as sources of learnings meanings of words. Thus a difference in the theory of the unit of meaning determines the source of learning meanings. It has become commonplace among contemporary Western philosophers to hold that dictionaries do not give word-meanings but explain word-meanings only in the context of a sentence. This, however, goes against the concept of lexicon in Sanskrit which gives only synonyms of words. Thus the very concept of lexicon or dictionary of a language changes according to the theory of meaning formulated in philosophical systems.

Language as Means of Communication

According to Navya-Nyāya, language used as a means of communication to be successful must ensure that the hearer understands what the speaker intends to convey. Language in this aspect is treated in Indian philosophy in general and Navya-Nyāya in particular as a source of second-hand information. To be a second hand source of knowledge is, according to Navya-Nyāya philosophers, to be the instrumental cause which produces the cognition of the sentence-meaning. The concept of meaning, therefore, is defined purely from the hearer's point of view giving a very minor importance to the speaker's point of view. If language as a means of communication is conceived as the instrumental cause which produces a certain cognition in the hearer, the concept of meaning is formulated only from the hearer's point of view. According to Navya-Nyāya philosophers, the speaker already has the knowledge which he intends to communicate to the hearer. Thus in the case of inference for oneself, the person completes the process of inference without using any words at all. When he wants to communicate his inference he uses a sentence with five members. It is the hearer who has to understand the meaning of the sentence; hence meaning is defined as the divine will which produces a certain cognition in the hearer on hearing the relevant word. Meaning of words conceived in this way completely ignores the intention of the speaker which becomes important only in understanding a sentence-meaning. Thus in word-meaning the speaker has no role.

Thus Navya-Nyāya philosophers like Jagadīśa have the problem of explaining how words which mean objects can yet mean a relational structure when they occur in a sentence. This is because words do not occur in isolation in a sentence. The cognition of the syntactical relations among words in a sentence is the only means of cognizing the semantical relations among objects meant by the words.

SOME ONTOLOGICAL PROBLEMS

Ontology of Spoken Sentences

I shall discuss here first the problem whether a spoken sentence can be regarded as a picture of what it means. One initial difficulty is that the structures of synonymous sentences in different languages are very different. So it is not clear which sentence of which language can be a picture of what it means. This difficulty is present in the case of written sentences also. Wittgenstein, for example, says: 'In Russian one says "stone red" instead of "the stone is red" ' (PI, p. 10e). This difficulty may be sought to be solved by formulating a symbolic canonical form of all synonymous sentences with different structures in different languages. But formulae of symbolic language, of symbolic logic, for example, are always written expressions. We have already discussed why written sentences cannot be regarded as pictures even by using conventions of projection.

There is, however, a more serious ontological difficulty about spoken words or sentences. One cannot speak a whole sentence or even a word of more than one syllable, one can only utter sounds in succession, when the first syllable or phoneme is uttered the second is not yet uttered. When the second is uttered the first sound has vanished. So it is impossible to speak a whole sentence as one entity. As uttered, sounds are necessarily successive, they cannot be regarded as pictures which are wholes of co-existing parts.

The Navya-Nyāya philosophers explain the experience of the common man who perceives a whole sentence. These philosophers make use of a special form of perception due to *jñāna-lakṣaṇa sannikarṣa* to explain how past sounds can also be said to be perceived. When one hears the sounds as successively uttered, one remembers them in their order. This memory of the earlier sounds functions as a *sannikarṣa* which together with the hearing of the last syllable or phoneme, produces the perception of the whole sentence. If such a special form of *sannikarṣa* is not admitted, can there be any explanation how a whole sentence can be perceived, through hearing

successive momentary sounds? There are different philosophical theories which I explain very briefly.

There are philosophers who distinguish between the act of speaking and a spoken word or sentence. They point out various difficulties in the Navya-Nyāya theory of perception of a whole word or sentence. If the last syllable presented together with impressions of the earlier syllables can cause perception (hearing) of the whole word or sentence, then even if the syllables are uttered with long temporal gaps in between, the perception of the last syllable together with the impressions of the earlier ones ought to cause perception of the whole word or sentence. But no one accepts this as a case of the perception of the whole expression. The case is not different even if the syllables are uttered in quick succession. Secondly, 'if the sounds are remembered in the same order in which they are uttered, how could they be simultaneously grasped'?⁷ Hence grammarians like Bhartṛhari do not accept the theory, that speaking is ontologically identical with what is being spoken. A spoken word or a sentence, according to this theory, is a type of reality different from speaking.

The theory that words are ontologically different from noises which can be uttered by a speaker involves difficulties of all sorts. One difficulty is how to explain whether a speaker speaking words and sentences performs two acts—producing sounds and speaking words. Then there is also the difficulty from the hearer's point of view. Does a hearer hear two things—sounds and words? The following three different answers apart from their own difficulties are inadequate chiefly because they fail to explain what the speaker does in speaking. (a) One answer is that sounds are heard as identical with words. There are no two objects which are heard when one hears words or sentences. But this answer does not explain how noises and words can be ontologically different and yet the hearer can hear them (correctly?) as identical. (b) The second answer is that sounds are imperceptible and only words can be heard. What is necessary and sufficient to explain the perception of words and sentences is that there be sounds, not that the sounds be perceived. A difficulty of this theory is that a deaf person who can not hear sounds should be able to perceive spoken words, if objectively there are appropriate sounds. (c) Words are manifestors of objects, and so different from mere sounds. When one hears the manifestors one also hears the sounds as fused with the manifestors. That is why a hearer does not hear two things, sounds and words. But when one does not clearly hear the words because they are, say, spoken at a distance, one hears only the sounds. Quine cites many examples of 'listening to a lecturer with an odd accent or unusual diction'. 'Accents may bewilder, and they can *cause*

misapprehension without bewilderment'.⁸ A difficulty of this theory is that it has to postulate two different causal relations—one for perception of words as fused with sounds, and another when they are not so fused.⁹ When we hear sounds we cannot hear the words, for perception of sounds prevents perception of words. Yet when we perceive words we also perceive sounds as identical with the words. But then the question is: if noises and words are ontologically different, words can at best be confused with, not fused with sounds. So the problem of reality of words confused with the ephemeral sounds producing correct perception of words remains.

An Ontological Problem Concerning Meaning

Language is about reality. The problem here is to explain how it is possible. This is a transcendental question as distinct from a factual one. Hence it cannot be solved by asserting that language is, as a matter of fact, about reality. In the usual analysis of meaning, this transcendental problem is presupposed as already solved. For example, Charles Morris says:

The process in which something functions as a sign may be called *semiosis*. This process . . . has commonly been regarded as involving three (or four) factors: that which acts as a sign, that which the sign refers to, and the effect on some interpreter in virtue of which the thing in question is a sign to that interpreter. These three components in semiosis may be called, respectively, the *sign vehicles*, the *designatum*, and the *interpretant*; the *interpreter* may be included as a fourth factor'.¹⁰ He has already assumed that there are signs, that there is an 'effect on some interpreter in virtue of which the thing in question is a sign to that interpreter'. He explains *this effect* behaviouristically thus. 'To use one of Mead's frequent examples, we may consider the situation of a person noticing smoke in a crowded theatre. Smoke is a non-gestural sign of fire, and its perception calls out to some degree responses appropriate to fire. But further, the spoken word 'fire', as a response which is connected with a whole set of responses to fire, tends to be uttered. Since this is a linguistic sign, the utterer begins to respond towards this tendency toward utterance as other member of his social group would respond—to run toward an exit' (p. 37). But this explanation of how a sound becomes a linguistic sign is not satisfactory. In the course of reacting to smoke as a non-gestural sign of fire, one may utter the sound 'fire' which is just an interjection. The passage from sounds as interjection to sounds as sign remains unexplained. Moreover, conditioned reflex is really a physiological process corresponding to the psychological process of association. The semantical relation between a word and its meaning is not *just* association, but a *special type* of association. The process of replacing a non-gestural sign by a verbal sign in response to an object or situation cannot be identified with semantical meaning, because in this process there is no scope for uniformity. It would be a mystery if everyone, or, a person always, uttered

the same word 'fire' when reacting to the non-gestural sign smoke, *before learning the word* which is not a semantically unrelated sound. Thus this behaviouristic theory of how a word is semantically related to its meaning already presupposes the theory that it is used by 'members of a social group' in very similar situations. But this is exactly what needs to be explained.

That meaning is neither a conditioned reflex nor a mere association can be shown by the example of Helen Keller. Helen was deaf and blind from early childhood. The problem was how to teach her language. If meaning were a conditioned reflex or an association, this could have been established by repetition. Her teacher failed to make her realize that the sign that she made on her palm *meant* the object which she experienced. The teacher almost gave up her attempt to teach Helen language. As a last resort, she thrust Helen's hand under water and made a sign on her palm at the same time. Somehow Helen understood that the sign made on her palm *meant* water. Once the concept of meaning was available to Helen, there was no difficulty in teaching her language. This case shows that meaning cannot be a conditioned reflex or mere association. Meaning is association of an altogether different kind. For example, the word 'light' may be associated with darkness (by contrast), with the sun or a lamp, or even with other words as in 'Hail holy light'! But all these associations do not constitute the meaning relation between the word 'light' and light.

This also explains why by simply observing the behaviour of an adult on the command of a senior person, a child cannot learn the meaning of sentences and eventually of words. For the child may get the idea that the behaviour and the spoken words are causally, not semantically, related. That is why St. Augustine has to say that the semantic relation is 'naturally' known by knowing 'the natural language' of man. The problem is how to know what a person does (by moving his hands, or by producing sounds), can be regarded as being *about* reality. A person's behaviour is his personal affair, perhaps causally determined by heredity and environment; how can one *ever* get the idea of a semantical relation between the personal actions (including speech behaviour) and reality? A sound emitted by a person may be an interjection, not necessarily a significant word. That a sound uttered by anyone can at all be about an object other than the sound is a mystery.

A theory which emphasises the conventional, rather than the causal-behaviouristic, factor in semantic meaning has also been proposed. But convention, as explicitly stated rules, is possible only when some language (a metalanguage) is available. But 'rules for the use of sign vehicles are not ordinarily formulated by the users of a language, or are only partially formulated; they exist rather as habits of behaviour' (p. 23). The problem is

to explain how 'habits of behaviour' are possible to begin with. Navya-Nyāya philosophers invoke God's will as semantically relating a word with its meaning. This is almost the same theory as a natural connection between words and objects which is also not man-made. But this seems to be very much like repeating the problem rather than solving it.

The metaphysical theory of semantic relation between word and object emphasizes the point that this relation cannot be explained except on the hypothesis that words as articulated sounds and objects which are altogether different types of reality on the surface, must be one reality at the deepest level of consciousness. Unless language as rooted in consciousness is fused with reality in one amorphous unity, language as articulate speech cannot *refer to, designate or mean* reality. Even at the surface level of articulate speech, language cannot be totally divorced from reality. Language as sound, and reality, are very different types of reality—the word 'fire' and fire are indeed very different—still the word 'fire' *can mean* fire, *can be* semantically related with it, only if we suppose that language and reality are one at the deepest level of human existence. Thus the *possibility* of semantic relation can be explained only on the hypothesis of the metaphysical unity of language and reality. This is the theory of the grammarians.

Nyāya philosophers, however, offer a different solution. They point out that God who has created both the words and objects can relate them semantically by his will. It is divine will which is the semantical relation. This also explains why in a particular language a particular word means a particular object. The grammarians explain why any word can mean any object, but not why a particular word means a particular object in a particular language. That meaning of words has a conventional aspect, is missed by them.

It may be argued that Bhartṛhari has also admitted conventional meanings of words. But this aspect of Bhartṛhari's theory does not seem to be consistent with its other fundamental aspects. According to Bhartṛhari it is the sentence which is real as an indivisible unit; the words are unreal appearances. So both syntax and semantics of words are unreal. As words are unreal, Bhartṛhari cannot also hold that words are semantically related to objects. Words are useful fictions; but they are fictions. Any fictitious entity cannot be related to objects which are empirically real.

NOTES AND REFERENCES

1. For example, in Sardindu Bandyopadhyaya's story 'the earthen lamp' (*mrit pradip*), the Queen Somadatta heard the different tunes on the flute, and learnt the secret message. When Chakrayudha Īśānavarma asked her how she could get the message from the tunes played on the flute, she replied that she knew the words in the tunes played, for the person who played the tunes was her music teacher.
2. 'Their intention was shown by their bodily movements, as it were the natural language of all peoples' (*Confessions* I, viii 13).
3. Gestures as para-linguistic behaviour may be used with speech to disambiguate. For example, if one says, 'bring *saindhava*' where the term '*saindhava*' means either salt or a horse. If one is taking food and says this, it is natural to suppose that salt is meant; but one may also intend to proceed on a journey immediately after taking food. So to disambiguate in this case, one may use appropriate gesture together with the word '*saindhava*'. If one points to the plate, then salt will be meant, if, on the other hand, one points outside, then a horse will be meant.
4. Why spoken sentences cannot be regarded as pictures of reality will be discussed later.
5. *Maunīślokaḍāvityādinā dūitvādibodhakavijātiya-hastaceṣṭādaḥ saṁgrahaḥ* (*Dinakari*, p. 545).
Padajñānasya karanatvam iti navinamatas tu liṭya hastaceṣṭaya ca saṁketitapada jñānam bhavati śābdabidha iti bhāvah (*Rāmarudrī*, p. 454).
Maunīkartika-vākyabodhaka-liṭyāḍāvityarthah. Ādīpadāt dūitvādibodhakahastaceṣṭādeḥ parigrahaḥ (*Prabhā*, p. 545).
6. *Nanu bhāṣāśābdānāmaṇi vācakatvameva, hasta-karādivad vinigamakābhāvāt. Na ca sarvadeśaikarūṇyaṁ; tat kiṁ sarveṣu deśesu saṁskṛta-vyavahārasatvam vā, yatra vyavahāras tattraikarūṇyaṁ vā, niyata-deśa-vyavahārābhavo vā. Nādyah kvacin mlechedeśe saṁskṛta-gandhābhāvāt. Dvītyasya bhāṣāsādharaṇyāt. Na tṛtīyah 'Śavatingatikarmā' ityādi-bhāṣyavirodhāt. Nāpi śiṣṭa-prayuktatvam vinigamakam bhāṣāsādharaṇyāt. Vastuta īśvareṇa sṛṣṭyādvārtha-viśeṣavaccabdaviśeṣa api sṛṣṭa eva, 'nāma-rūpe vyākaroṭ iti śruteḥ/ Na hi tadānimsaṁskṛtam eva sṛṣṭam na bhāṣāntaram ity-atra mānam asti. Tattad-yavanādi-sṛṣṭau tadīya-bhāṣyā api tadānim eva sṛṣṭatvāt. Na hi teṣāṁ api prathamam saṁskṛtenaiva vyavahārah, paścād apabramśa-rūpa-bhāṣa-pravṛttir iti kalpanāyām mānam asti* (*Mahābhāṣya* with *Pradīpa* and *Annambhaṭṭa's Uddyotana*, Part I, Govt. Oriental Mss. Library, Madras, 1948, p. 47).
7. K. Kunjunni Raja, *Indian Theories of Meaning*, p. 110. The Navya-Nyāya philosophers, however, reply to this objection by pointing out that the memory impressions of the sounds in their spoken order are the causes of the resulting perception of the word as a whole.
8. Quine, *Quiddities*, pp. 166–7.
9. 'Speaking with an eye to speech is one thing, and speaking with an eye to content is another'. Quine, *ibid.*, p. 167.
10. *Foundations of the Theory of Signs*, vol. 1, no. 2, p. 3.

Methodology: On Self-criticism

DEBIPRASAD CHATTOPADHYAYA

Permit me please to begin with a point which may appear to be rather extraordinary, and at any rate is not generally discussed in works on Indian culture. There is a special difficulty for an *Indian scholar* to try to probe into the scientific activities of ancient India—a difficulty from which a visiting scientist is understandably free. Before passing on to analyse the reasons and remedy for this, let us have a specific example.

The most outstanding visiting scientist to India before the modern period was Alberuni. Born in AD 973 in Persia, he came to India in 1017 as a 'prisoner of war' or as a 'hostage' of King Mahmud of Ghazni, 'kept on honourable terms' and spent thirteen years in this country. He already had the reputation of an astrologer-astronomer, which perhaps helped him to have relations with the court and its head as Tycho de Brahe with the emperor Rudolf. In any case he had the opportunity of conversing with Indian pandits, of procuring their help and of buying books. Already a master of Arabic literature and also of Greek as translated into Arabic, Alberuni acquired vast knowledge of Sanskrit and became highly efficient specially in astronomy, mathematics and philosophy of the Indians. He wrote a book on India which is remarkable for its encyclopedic range. We are indebted to a Sachau for a magnificent English translation of it along with a penetrating preface. What specially concerns us here is the attitude to Indian culture as recorded in Alberuni's survey of India. He completely dissociated himself with Mahmud and his plundering raids. 'To Alberuni the Hindus are excellent philosophers, good mathematicians and astronomers, though he naively believes himself to be superior to them.'

The enthusiasm he had for Indian philosophy, which he diligently cultivated, appears to us to have been somewhat strange, specially when we remember that he was himself a devout Muslim always appealing to the authority of Quran. As Sachau sums up, 'He seems to have revelled in the pure theory of the *Bhagavadgītā* and it deserves to be noticed that he twice mentions the saying of Vyasa, learn 25 (i.e. the elements of existence) by distinctions etc. Afterwards adhere to whatever religion in life, your end will be salvation.' In one case, he even goes so far as to speak of a Hindu scholar as 'enjoying the help of God, which to a Muslim means as much as inspired by God, guided by divine inspiration. These words are in addition to the author's in his paraphrase of the *Bṛhat Saṃhitā* of Varāhamihira, v 8. There can be scarcely any doubt that Muslims of later times would have found fault with him for going to such length in his interest for those heathenish doctrines.'

With his own profound religious sentiment Alberuni was also intensely committed to natural science—specially to astronomy and mathematics, in which he acquired remarkable proficiency. What he had no patience at all was fraud for cheating people, say by verbosity of the priests or wild tales about alchemy like attaining physical immortality or creating gold.

More points may easily be mentioned to establish that Alberuni could not have any special anxiety to vilify an Indian scientist. Yet, he noted something extremely strange about two of the foremost Indian astronomers. This he found while discussing the understanding of the eclipses. 'It is perfectly known to the Hindu astronomers', he observed, 'that the moon is eclipsed by the shadow of the earth, and the sun is eclipsed by the moon. Hereon they have based their computations in the astronomical handbooks and other works.'

In substantiation of the statement Alberuni quoted at length from the famous *Bṛhat Saṃhitā* by Varāhamihira, who flourished in c. AD 505–587. Asserted Varahamihira:

v. 8: As has been mentioned by scholars who enjoy the help of God, an eclipse of the moon is her entering the shadow of the earth and an eclipse of the sun consists in this that the moon covers and hides the sun from us. Therefore the lunar eclipse will never revolve from the west and the solar eclipse from the east.

Such an assertion was obviously in flat contradiction to the popular belief based on the mythology of the earlier days, according to which Rāhu, imagined to have been just a Head without the body, occasionally gobbles the Sun and the Moon for some time and that was the cause of the eclipses.

Varāhamihira understandably found it necessary to scrap such an ancient view as but imaginary. So he observes: 'the nature of the Head has nothing whatever to do with the lunar and solar eclipses. On this subject the scholars in their books agree.'

As in Indian mythology the demon Rāhu as mere Head, has no other function than causing eclipses, it simply follows from Varāhamihira's assertion that such a demon was a purely fictitious one or a product of primitive ignorance. But Alberuni notes an extremely queer point. The Head, though having no reality, had nevertheless a spell of stupendous authority even on as renowned an astronomer as Varāhamihira. Failing to outgrow such an authority Varāhamihira went on to try to explain the Brahmanical views of the theory and practice connected with Rāhu.

Observed Alberuni:

After having described the nature of the two eclipses as *he* understands them, he complains of those who do not know this and says however, common people are always very loud in proclaiming the Head to be the cause of an eclipse, and they say: if the Head did not appear and did not bring about the eclipse, the Brahmins could not at that moment undergo an obligatory washing.

Since the Head for Varāhamihira's scientific analysis was in fact no more than the product of primitive ignorance, the least that is expected of him is obviously an outright rejection of the popular belief and the Brahmanical practice. Strangely however the astronomer did not at all go in for this. What he actually did was the most incredible rationalising about the theory and practice concerning the celestial monster. As he observes:

... the reason of this is that the Head humiliated itself after it had been cut off and received from Brahman a portion of the offering which the Brahmins offered to the pyre at the moment of an eclipse.

Therefore he is near the spot of the eclipse searching for his portion. Therefore at that time people mentioned him frequently, and considered him as the cause of the eclipse, although he has nothing whatsoever to do with it; for the eclipse depends entirely upon the uniformity and the declination of the orbit of the moon.

More passages are quoted by Alberuni to show the flat contradiction in Varāhamihira's standpoint. The popularly assumed cause of the eclipse is no more than a myth, yet, it is very much there to receive some portions of the offering made by the Brahmins. Alberuni himself proposes to show a peculiar tolerance for Varāhamihira's abject self-contradiction. 'The latter words of Varāhamihira', he observes, 'who, in passages quoted previously, has already revealed himself to us as a man who accurately knows the shape

of the World, are odd and surprising. However, he seems sometimes to side with the Brahmins to whom he belongs and from whom he could not separate himself. Still he does not deserve to be blamed, as, on the whole, his foot stands firmly on the basis of the truth, and he clearly speaks out the truth.'

But let us leave Alberuni's tolerance for Varāhamihira and turn to ourselves. The *Brhat Samhitā* is after all by far the most widely circulated work on astronomy (astrology) among the Indian scholars, traditional as well as modern. Heaps and heaps of studies in it are produced in the country, yet nowhere is taken any notice of this howling absurdity in the text. It is simply overlooked or bypassed by the Indian Pandits.

Varāhamihira was succeeded among prominent Indian astronomers by Brahmagupta, who wrote his *Brahmasiddhānta* at the age of 30 in AD 625. He is generally considered to have been the greatest of the Indian astronomers, an assessment to which Alberuni subscribed. But then a stranger absurdity in his work is noted by no Indian scholar before or after Alberuni, though Alberuni himself came out very sharply against it. We shall have to quote him at some length.

But look for instance at Brahmagupta, who is certainly the most distinguished of their astronomers. For as he was one of the Brahmins who read in their Purāṇas that the sun is lower than the moon; and who therefore requires a head biting the sun in order that he should be eclipsed, he shirks the truth and lends his support to imposter . . . the words in question are found in the first chapter of his *Brahma-Siddhānta*.

Some people think that the eclipse is not caused by the Head. This however is a foolish idea for it is *he* in fact who eclipses, and the generality of the inhabitants of the world say that it is the Head who eclipses. The Veda, which is the word of the God from the mouth of Brahman, says that the Head eclipses, likewise the book Smṛti composed by Mānu, and the Samhitā composed by Garga, the son of Brahman. On the contrary, Varāhamihira, Srisena, Aryabhaṭa and Vishnucandra maintain that the eclipse is not caused by the Head but by the moon and the shadow of the earth, in direct opposition to all (to the generality of men), and from enmity against the just mentioned dogma. For if the Head does not cause the eclipse all the uses of the Brahmins which they practise at the moment of the eclipse, viz. they are rubbing themselves with warm oil, and other works of prescribed worship, would be illusory and not be rewarded by heavenly bliss. If a man declares these things to be illusory, he stands outside the generally acknowledged dogma, and that is not allowed. Manu says in the Smṛti: 'when the Head keeps the sun or moon in eclipse, all waters on earth become pure, and in purity like the water of the Ganges'. The Veda says, 'the Head is the son of woman of the daughters of the Dvaityas' . . . therefore people practise the well-known works of piety, and therefore those authors must cease to oppose the generality, for everything which is in the Veda, Smṛti and Samhitā is true.

Comments Alberuni:

If Brahmagupta, in this respect, is one of those of whom God says (Koran Sura xxvii. 14), 'They have denied our science although their hearts know them clearly, from wickedness or haughtiness', we shall not argue with him, but only whisper into his ear: If people must under circumstances give up opposing the religious codes (as seems to be your case), why then do you order people to be pious if you forget to be so yourself? Why do you after having spoken such words, then begin to calculate the diameter of the moon in order to explain her eclipsing the sun, and the diameter of the shadow of the earth in order to explain its eclipsing the moon? Why do you compute both eclipses in agreement with the theory of those heretics and not according to the views of those with whom you think it proper to agree?

Alberuni himself wanted to explain the obvious anomaly in the writing of such a talented astronomer and he observed: 'I, for my part, am inclined to the belief that which made Brahmagupta speak the above mentioned words (which involve a sin against conscience) was something of a calamitous fate, like that of Socrates which had befallen him, notwithstanding the abundance of his knowledge and the sharpness of his intellect and notwithstanding his extreme youth at the time. For he wrote the *Brahma-Siddhānta* when he was only 30 years of age. If this indeed is his excuse, we accept it, and herewith drop the matter.'

When Alberuni compares Brahmagupta's position to the calamitous fate of Socrates, there is evidently a tone of subdued tolerance in his words. One wishes that some Indian scholar noted the contradiction in Brahmagupta's work, with or without sympathy. But there is not a word from them and the matter is left to be judged only by a visiting scientist. Evidently, the Indian scholars have a peculiar limitation when they try to discuss the situation in science in ancient India. There is something that makes them blind, from which a visiting scientist is understandably free.

What then is this limitation and how are we expected to overcome it?

An Indian historian of Indian science is above all a citizen of India. As such he cannot be fully free from the preoccupation generally characterizing traditional Indian intellectual atmosphere and coming down more or less in the same form even to our time. Such an atmosphere is a complex phenomenon—some elements of it are helpful for the cultivation of science, others hinder it. As a contemporary citizen of India, it is however difficult for him to be fully critical and discriminating. What operates here is a some kind of an all-or-none law. This means that the dregs of a dead past also come down to him, professing to be characteristic of the Indian culture. It is in such an atmosphere that he is born, he breathes, and grows

up, without any natural urge to discriminate between what is living and what is dead in the general intellectual atmosphere in which he grows up. The professed objectivity of an Indian scholar, if claimed to be absolute, is thus an illusion. But he can be more or less objective in so far as he is consciously critical. This should make him enthusiastic, e.g., of the astronomical calculations indicative of the actual causes of eclipse, while scrapping the old myth about Rahu or the Head. But this is not easily done. The Rāhu or the Head comes down to him as part of the scriptural declaration which he accepts unconsciously, if not consciously. The spell of the hoary texts, continuously declared by the Brahmins to be scriptural revelations, is not easily outgrown. In 1968 the then Prime Minister of India rightly complained that even our working scientists live some kind of a split personality—accepting science in their professional life and the opposite of science in their private life. One may as well wonder how many of our talented mathematicians and astronomers today, while going much deeper than Varāhamihira and Brahmagupta in their understanding of the eclipses, allow in their houses the rituals prescribed in the scriptures to be observed during the eclipses. I am afraid the majority of them do not completely scrap it and that is sure to affect their understanding of ancient science. For obvious reasons however, a visiting scientist like Alberuni is free from any such obligation and can objectively observe and comment on the absurdities of Varāhamihira and Brahmagupta which, though on the surface, tend to elude the notice of the Indian scholars and historians.

This brings us to the main point we have been trying to discuss. It is concerning the need of a good deal of self-criticism for an Indian scientist to probe into the scientific past of India. In a country like ours with a cultural tradition stretching over more than 2000 years there had been astonishing achievements in science just as there was a good deal of anti-science or superstition masquerading as divine knowledge or scriptural declaration. There is always a danger for us to be lured by the will-o-the-wisp, only to be betrayed into the mire of self-deception. For a historian of science in ancient India it is thus not enough to be Pandit in the ancient texts nor also in the mere analysis of their subtle implications. What is moreover needed is a conscious cultivation of the spirit of self-criticism so that he is not easily misled into the acceptance or even tolerance for the dead weight of the past, surviving in his mind and professing a religious aura.*

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Reflections on the Proposal: 'A History of Science, Philosophy and Culture in Indian Civilization'

RAVINDER KUMAR

It is more than three years since Professor D.P. Chattopadhyaya placed before scholars, drawn from different disciplines in the human and in the natural sciences, a seminal proposal seeking to create a multi-volume history of science, philosophy and culture in Indian civilization.¹ This proposal flowed out of the reflections of a distinguished humanist upon some of the principal constituents of our civilization; their trajectory over a vast temporal and physical landscape; and their implications in the 'here' and 'now', as well as in the decades which lie ahead, for the people of India and, indeed, for humanity as a whole. Since it was launched, the proposal has been discussed at a number of meetings, where its richness and significance have been reinforced through a wealth of conceptual interventions by some of the most incisive intellects in our country. The time is, therefore, opportune to take stock of the original proposal; to dwell also upon the wide ranging discussions it has stimulated; and through a creative fusion of the former with the latter, spell out a concrete programme of activity seeking the realisation of Professor Chattopadhyaya's intellectual vision.

Before I proceed to outline various modes of exploring the scientific and cultural heritage of Indian civilization, it would be appropriate to dwell upon the reasons which may have influenced the formulation of the proposal whose significance and realisation we have decided to discuss. Perhaps the historical imagination, as it is defined later in this essay, is of some assistance to us in such an endeavour. In a very literal sense of the term, we are located in a temporal conjuncture when a profound crisis in the human

conditions is also accompanied by an equally profound crisis in the cognitive content of the human as well as the natural sciences. As a result of reflection and enquiry over centuries, some of the greatest intellects in the history of humanity were successful in generating social theory in various domains which stood us in good stead for a substantial period. Whether these theories touched upon conservative modes of societal transformation and spiritual praxis; or they reached out to liberal life-styles and modes of social production; or, once again, whether they underpinned radical worldviews seeking to reshape human destiny in the material no less than in the cultural domain; such understanding about the human condition, and how it could be transformed, appeared to provide reasonably satisfactory solutions to most of the dilemmas faced by reflective no less than by social actors. Even when the exploring mind ventured out to the frontiers of empathetic enquiry and rational comprehension, Socratic wisdom about the limits of the known, or the knowable, as Werner Heisenberg demonstrated with such felicitous logic in the natural sciences, held out the prospect of novel breakthroughs in the range and depth of cognition and praxis.

As we draw closer to the third millennium in the history of mankind, however, our knowledge and understanding of ourselves and our environment, social, natural and spiritual seems to be wholly inadequate to the challenges which stare us in the face. There is, flowing from such a profound crisis, a pressing need for clearing the decks (as it were); and generating out of the unresolved dilemmas of our times, a discourse, or worldview, which shall provide the basis for enriching our understanding and reinforcing our capacity for social action and spiritual realisation.

I

It would be legitimate at this juncture to review earlier scholarly efforts, comparable to ours, as we proceed to shape the possible outlines of our project. The first notable fact about these efforts lies in that they were located, without any exception, within Western (or more specifically, European) civilization. I refer, in the first instance, to the great intellectual movement within French society which generated the first of the modern *Encyclopaedias*.² Here was a remarkable attempt by a group of French thinkers to organise, on Cartesian assumptions, all available knowledge about the natural and the social universe. Behind such a monumental exercise lay the conscious decision to summarily reject the medieval discourse of the sacred and the profane, as reflected in the awesome authority of the Christian Church. Behind it also lay the attempt to reach out to secular modernity in

its profound potential and full splendour. Denis Diderot and his co-workers accepted as a fundamental truth the belief that the universe was underpinned by a grand natural design, which could be grasped much more accurately and readily through the faculty of human reason than it could be grasped through the exercise of intuition resting upon the sacred impulse. The Encyclopaedists also held out a concept of moral and material progress which rested, not upon a transcendent, timeless and sacral principle, but upon intellectual resolution, upon the discourse of science and upon the growth of social and political institutions. Their great objective was to realise the good life in the 'here' and 'now', rather than in worlds beyond. But perhaps the aims of the movement can best be expressed in the words of its principal architect:

The aim of an encyclopaedia (stated Diderot) is to gather together the knowledge scattered over the face of the earth, to set forth its general plan to the men with whom we live and to transmit it to the men who will come after us, in order that the labour of past centuries may not have been in vain in those that follow, that our children, better informed, may at the same time become happier, and that we may not die without deserving well of mankind.³

No less significant, as a triumph of the spirit of modernity, was the great undertaking, described as the *Cambridge Modern History*, which was initiated by Lord Acton in the last quarter of the nineteenth century. At the juncture when Acton embarked upon his intellectual labour, the victory of science over religion and of reason over faith seemed to be complete; and this victory proclaimed, in positivism, the crystallization of a discourse which ostensibly marked the ultimate triumph of the great Age of Liberalism. The supreme self-confidence of this age is eloquently reflected in a circular letter which Acton wrote to the Contributors to the *Cambridge Modern History*.⁴ Staking a claim to a level of absolute truth and objectivity, which seems in hindsight wholly untenable, Acton observed:

Our scheme requires that nothing shall reveal the country, the religion, or the party to which the writers belong.

It is essential not only on the ground that impartiality is the character of legitimate history, but because the work is carried on by men acting together for no other object than the increase of accurate knowledge.

The disclosure of personal views would lead to such confusion that all unity of design would disappear.⁵

Small wonder, then, that reflecting upon the certitude which informed the intellectual labour of the men who had created the original *Cambridge Modern History*, someone nearer our own times has commented:

Acton, in fact, reserves to the historians a role which Christian doctrine assigns to God Himself: omniscience and final judgment.⁶

Acton and his colleagues leaned heavily upon the supremacy of human reason and the categorical authenticity of the knowledge generated through its application to social and natural phenomenon. In making such assumptions, they were doing little more than extending the worldview of the eighteenth century—the discourse of the enlightenment—to the high bourgeois world of the late nineteenth century. All that is relevant to note in this context is the self-confidence, bordering upon arrogance, which the triumph of science and technology, as reflected in a great increase in the productive capacity of Western man, instilled in the voice of humanists who were also positivists at this juncture.

Yet the substantive novelty of the historical literature inspired by Acton, if it is compared to the work generated by Diderot, lies in the domain of temporality. This notion of temporality was shaped by the historical mode. At one level, the consciousness of linear temporality is something which is very deeply entrenched in the Judaic-Christian tradition, from its very inception. But the secularization of this consciousness, which commenced with the Age of the Enlightenment, if not even earlier, attained a new dimension in the work of scholars like Ranke, who deeply influenced Acton. We have already indicated the necessity of touching upon the attributes of the historical mode, as one of the crucial attributes of modernity, later in this essay. Suffice it to mention here that the historical consciousness which informed Acton was substantially different from that which informed Diderot in two significant respects. In the first instance, Acton had, thanks to Ranke, a radically new view of the raw materials, *i.e.*, archival sources, which constituted the legitimate basis of historical writing. Over and above this, the liberal discourse which sustained Acton, linked the past to the present through a chain of cause and effect, which was not necessarily explicit in the creative work of the men of the encyclopaedia. All told, therefore, despite the over-arching assumptions which Acton and his associates shared with Diderot and his co-workers, the creation of the *Cambridge Modern History* marked a radical advance within the liberal domain over the appearance of the first encyclopaedias.

In our brief review of compendiums of knowledge, created in the spirit of liberal modernity, it is necessary to dwell upon one more significant scholarly initiative located fairly close to us in time. We refer to Joseph Needham's majestic *Science and Civilization in China*, which appeared in the second and third quarters of the twentieth century. Despite his radical worldview, it would be valid to suggest that the basic assumptions which

informed Needham were not qualitatively different from those which informed Acton or Diderot. The real novelty of Needham's venture lay in the differing physical locus of the social and natural phenomenon, *i.e.*, the science and culture of China, which he sought to draw into the landscape of the European intelligentsia. 'The Chinese contribution to science and technology,' Needham pointed out in his Preface, 'remained clouded in obscurity. The very term "Far East" to denote China, which I shall not use again in this book, but which springs spontaneously to the written page, exemplifies that fundamental insularity of outlook which is so difficult for Europeans . . . to discard. The scientific contribution of Asia, and, in particular that of the "Central country", China, is the theme of this work'.

Even though Needham's originality lies in the physical locus rather than in the discourse which informs his work, several features of *Science and Civilization in China* deserve to be noticed at this juncture. At the very outset, what is implicit in the exercise needs to be made explicit. There is almost no attempt on the part of Needham and his colleagues to explore the philosophical autonomy (from the West) of Chinese civilization. Indeed, as already suggested, Needham ingeniously co-opts into the paradigms of European thought, in the radical modernist mode, the reflective vision and the utilitarian arts of China across the centuries. He comments with interest upon the profound scientific knowledge of China in the first millennium AD; at the same time as he comments upon 'the inhibiting factors in Chinese civilization which prevented a rise of modern science in Asia analogous to that which took place in Europe from the sixteenth century onwards, and which proved one of the basic factors in moulding the modern world order.'⁸ We may, later in this essay, hark back to the formulation of Needham, as we attempt to delineate the trajectory of scientific and humanist culture in our own civilization, at the same time as we seek to highlight its conceptual autonomy from *and* creative interaction with Western paradigms in the twentieth century.

. II

The proposal to create 'A History of Science, Philosophy and Culture in Indian Civilization', has, so I believe, a potential significance comparable to that of the seminal undertakings spelt out above, which are veritable landmarks in the intellectual growth of humanity. Yet in spelling out the significance of the proposal, it is also necessary to emphasize the manner in which it differs from the earlier undertakings. At the very outset, we are seeking to initiate a substantial intellectual exercise which is located, both

in terms of space and of discourse, outside the framework of that European civilization which has dominated humanity for virtually half a millennium. Scholars who may be drawn into this activity have the advantage of acquaintance with systems of discourse, European and Indian, which was denied to the creators of the different projects spelt out above. The awareness of such a rich range of philosophical concepts holds our possibilities of approach and analysis which were altogether ruled out in the earlier exercises.

Another striking feature of the project under review, too, deserves notice. This concerns the truly comprehensive range of social activity and cultural production which those drawn into the project may seek to analyze. As its title suggests, the majesterial series created by Needham was, in some ways, limited by a refusal to dwell upon culture, in its full social and reflective manifestations, when the history of science and technology in China was explored. As against this, the French Encyclopaedists and the first liberal historians of modern European society, namely, Acton and his colleagues, deliberately fragmented human experience and knowledge, for facilitating enquiry and analysis, in the mechanical and, therefore erroneous assumption that the subsequent aggregation of the fragments in a comprehensive narrative would somehow recapture the whole. We shall have more to say about fragmentation of social experience as the great flywheel of epistemology in the human and the natural sciences, later in this essay. Suffice it to mention here that we subscribe to the philosophical assumption that the whole is not an arithmetic sum of the past. For this reason, the treatment of 'Science', 'Philosophy' and 'Culture'—we shall attempt to define these three concepts later—in a conjoined manner is a conscious statement about a distinctive mode of the generation, no less than of the comprehension, of knowledge about man, nature and sacred and profane worlds.

We need to refer to one or two other questions before we touch upon the substantive concerns of this essay. It has been mentioned earlier that, over and above the intrinsic significance of the present exercise, its location in time is also a matter of the utmost importance. Indeed, it would be no exaggeration to state that Indian society stands at a crucial stage in its search for modernity. This search relates to much more than the limited creation of institutions and technologies of production, of degeneration of social and political institutions, which seek to drop the vitality of the popular classes into the creative endeavour of society as a whole. Our notion of modernity reaches out as much to cultural creativity and spiritual reflection as it reaches out to social production and political representation in a community. Moreover, in any such quest for modernity—and it is our assump-

tion that we are searching for modernity as defined above—the relationship between the old and the new, between the past, the present and the future; are matters of central significance. Our project seeks to keep this relationship very much in focus, as it explores the unfolding destiny of those countless men and women, whose ceaseless toil, no less than whose aspirations constitute the true basis of our civilization. In doing so, the pivotal role of intellectual enquiry and the perennial quest for self-realization will constitute an important facet of our project, as the same time as we focus upon the development, or absence thereof, of formulations of scientific and technological culture within our civilization. There is, finally, reason to believe that the location of a liberal spirit in our worldview facilitates a relationship between tradition and modernity to which there is no parallel in the Western experience. These are some of the factors tangible and intangible, upon which a focus is necessary as we seek an understanding of our past in its causal relationship with the present.

I shall dwell upon more issues before taking up the specific themes of the project under consideration. In its original formulation, the process for a history of science, philosophy and culture in India refrained from mentioning the place of praxis in our scheme of things. Perhaps such a coyness stemmed from a sensitive awareness of the organic linkage between cognition and praxis in the destiny of human societies. We have emphasised earlier the historical conjuncture of our project, over and above its intrinsic significance, and its comparability, in scale and significance, with some of the crucial ventures undertaken by scholars in the past. We would further argue that our project has a relationship with India's quest for modernity, in sense suggested earlier, which it would be valuable to highlight at this juncture. The quest for modernity in India comes at a moment when liberal/radical wisdom about the character of human societies, and the principles which govern their transformation, seems to be unequal to the task which it confronts. All the more reason, therefore, why we should not be drawn into our undertaking on principles which may rest upon tenuous grounds. Instead, we should attempt to reach out to a novel discourse which deepens our comprehension of our historical heritage, at the same time as it provides those means for social reconstruction and cultural transformation which we have been seeking in our recent history.

III

It has been suggested earlier in this essay, that it is necessary to arrive at tentative definitions of the terms 'science', 'philosophy' and 'culture', with

which we are so crucially concerned in our exploration. But even more crucial than these terms, as we have also held out, is the historical mode of thought and cognition, which constitutes the central axis around which social comprehension, scientific knowledge and creative praxis is organised in modernity.

At the very outset, it should be emphasized that the mode of philosophical discourse reflected in the title of our project, namely, the historical mode, is substantially alien to the intellectual traditions of our civilization. Now the character of history and its precise configuration, today, are questions with which we shall deal later. But it follows from what has been suggested above that the alienness of historical thought makes it a distorting mirror, if it is held up to Indian society, in order to elucidate its essential character as well as the dynamics of its transformation across time. Yet a bold act of historical transcendence is probably a legitimate way of understanding our society, at the same time as it facilitates the location of strategies of social transformation along desirable lines.

The central feature of any historical exploration is the enunciation of a temporality which is not a part of our cultural heritage. For as is well known, the concept of time in the Indian tradition is either circular and repetitive, or fuzzy and vague.⁸ The former is often articulated in the sacred texts, while the latter is much more a product of popular consciousness. Starkly opposed to circular or fuzzy concepts of time, is the definition of temporality along a linear axis, which is further parcelled out into discrete, invariable and measurable units. In its full rigour, such a notion of secular time, as a calibrated and linear axis, acquired maturity with the dawn of modernity in Western society. Indeed, the conceptualization of time in such a framework was linked to the dawn of a new era of social production and political central, namely, the era of industrialization and the nation-state.

Over and above the notion of linear temporality, the crystallization of modernity also assumes a nexus of rationally discernible cause and effect as the great flywheel of the social process. The 'tightness' of this causal relationship is variously interpreted by scholars ensconced in the discourse of modern historiography. Some are inclined to argue that the causal chain underpinning the flow of history is so rigorous, that it is possible to chart out formal laws of history, which draw the past, the present *and* the future of humanity into a well defined and fully comprehensible design. Others (and I belong to this school), subscribe to the view that the interjection of the fortuitous, or the irrational, in the flow of social phenomena render the future a relatively open book, despite the rigour with which the past, or what

has already happened, can be explored and comprehended. Be that as it may, the two notions of linear and scaled temporality, on the one hand, and the causal mechanisms which underpin the social process, on the other, constitute the basic pillars of historical thought as one of the seminal constituents of modernity.

These two notions are conspicuous by their absence within the Indian tradition. A textual analysis of the literature, sacred and profane, generated in the pre-classical or classical centuries within Indian society, makes it obvious that the notion of temporality was conceptualized in a wholly different manner. Among the fold, there was an assumption, in a manner of speaking, about an undifferentiated past in which philosophical reflection and scientific creativity were telescoped into a discursive heritage that shaped mentalities and provided the motive power for social engineering. The scrutiny of texts brings to light an alternative view that time and the historical process pursued a circular rhythm, wherein there was a return, after a certain interval, to a locus coincident with the starting point of human creation.

In contrasting notions of temporality within the Western tradition and the Indian tradition, it is necessary to emphasize a few points. First, as already hinted, the modern notion of time is closely related to work rhythms, to the organisation of social production and to political order in the age of industrialization. Second, that the concept of time within the Indian tradition rested upon a worldview which refused to privilege innovation and transformation as social categories which were morally desirable and socially beneficial. Such an emphasis upon social engineering and technological innovation are the distinctive features of modernity.

Since we have placed such emphasis upon the centrality of the historical sensibility to our project, it would be appropriate to say something about the reconstruction of the past at this juncture. Nobody knows better than the liberal scholar, immersed in the spirit of modernity, that the past can be constructed in a number of ways. It is also self-evident that all such constructions are, in a manner of speaking, products of the historical imagination. They are, moreover, instruments of praxis in the present; since they can in no way affect the past. Hence the well known diction that 'all history is contemporary history. The past constructed by liberal or radical or conservative historians has very little to do with the "past" as it "actually was". For it is theoretically possible to construct an infinite number of pasts of a society. The particular past which is invoked, and successfully claims the attention of the community to which it is related, reflects a choice in praxis

and influences the future of a society. Paradoxically, therefore, a discipline like history, which ostensibly deals with the past, is in reality the most 'futuristic' of all the human sciences.

IV

While focussing on the strategic place occupied by temporality in historical thought, as conceived in the discourse of modernity, it is necessary to make a few observations about some seminal developments in the human sciences in our times. It is also necessary to dwell upon the problems which could stem from underpinning an appreciation of Indian civilization, with a temporal sensibility which is alien to its traditions and character, in the remote as well as in the proximate past.

If the dominant temporal discourse of modernity is manifested in linear time, then in a post-modern era, when liberal and radical theory is increasingly incapable of providing satisfactory answers to the problems confronting humanity, it is clearly necessary to take account of other concepts of temporality. We may, for instance, consider mythic time. It would be necessary, for this purpose, to briefly define the mythic notion of time. As already hinted, mythic time does not rest upon a linear axis, scaled into discrete and equivalent units of temporality. Instead, mythic time is drawn to a psychic rhythm which steers the causal flow of events along a circular trajectory, over and over again, to the point of commencement.

From our delineation of mythic time, it should be clear that any attempt to relate the trajectory of human history, in a simplistic fashion, exclusively to the time frame of liberal historiography, would be unsatisfactory both in empirical richness and in conceptual rigour. For these reasons, any total acquiescence in linear time tends to inhibit rather than to promote understanding and praxis. This is so because the human actors in any given situation are existentially ensconced in multiple notions of time, in their interior life as well as in the externality of their social placement. Nothing illustrates our argument better than the work of creative writers like James Joyce and Virginia Woolf, among others, who explore the interior lives of their fictional characters with a sensitivity and authenticity to be found not at all in the works of those writers of fiction who accept a simplistic notion of linear time as the only relevant concept of temporality.

The problem is compounded all the more, so far as the project under consideration is concerned, by the marginal lodgement of modernity in the fabric of Indian civilization over the centuries. In this context, it would be

legitimate to briefly explore notions of temporality in the classical centuries, when a substantial corpus of thought in Indian philosophy crystallized in the form of the texts which constitute our heritage. Taking into review also heterodox metaphysics of *śramanic* origin, it would be valid to hold that the different notions of time, as conceived by modernity, were conspicuous by their absence in the Indian tradition. We have also spoken of partially differentiated notions of time; highlighted through the use of the term *fuzzy*, a state of affairs wherein a sense of linear flow is unaccompanied by any sense of scalar gradation into equal and discrete units. It is, indeed, arguable that for the common folk within Indian civilization, the dominant temporality was the one marked by fuzziness: wherein the present was preceded by an undifferentiated past, innocent of the discrete and scaled units of time, which characterized the phenomenon in liberal discourse. It would also be valid to suggest that the texts of high culture, which probably influenced only the literate and the powerful, held out a circular notion of time in which social and natural phenomena were enmeshed in a repetitive cosmic cycle.

When we are examining the vexed question of temporality, in the context of Indian civilization, both the contemporary breakdown in the liberal concept of time in the West and its visualization in our tradition need to be kept in view. The ambiguity of the notion of time places before the scholar the explicit possibility of treating the simultaneous and overlapping presence of different modes of temporality, as the most authentic basis of scientific exploration and humanistic reconstruction. It is all the more essential to portray the trajectory of Indian civilization through such conscious ambiguity, since the temporal anomie of post-modernism is so powerfully echoed in our own tradition. Yet a distinction needs to be made between post-modern temporality and a state of societal existence in which the linear time of modernity was known not at all. The temporality of post-modernity carries with it a conceptual baggage of multiple and overlapping notions of time. Perhaps such a notion of temporality, wherein the scholarly psyche marries linear with other modes of time, at the same time as it transcends all these notions, is the most appropriate temporal discourse for our project.

V

Our brief review of temporality, and its location in any critique of Indian society, clears the ground for defining some of the concepts which feature so prominently in our project, namely, 'Science', 'Philosophy', and 'Culture'. Over and above this, it may also be appropriate to say a few words about

the notion of a 'civilization', and how it relates to the historical identity of Indian society.

In view of its centrality to the project, it may be valid to seek a tentative idea of the concept 'civilization' in the first instance. Here it is also relevant to note that though India is defined as a Nation-State in the vocabulary of contemporary politics, historically speaking, the only way in which we can conceptualise our society is to define it as one of the autonomous world civilizations.⁹ A civilization, so I believe, is a substantial segment of human society characterized by three organically linked constituents: First, by a mechanism (or mechanisms) of wealth generation which sustain(s) its members; second, by distinctive social and political institutions; and lastly, by a moral vision (or a plurality of such visions) which shape(s) the popular psyche. All these three constituents, taken integrally, determine the identity of a civilization. It need hardly be observed that the civilization of India rested in the past, and still rests substantially, upon small scale production by peasants as the basic source of wealth generation; just as it has distinctive social and political institutions; and a plurality of visions interacting with each other to constitute a coherent discourse.

After mapping out the distinctive features of Indian civilization, we can proceed to elaborate the three concepts which constitute the nodal reference points of our inquiry. The 'scientific' knowledge reposed in a culture pertains to the totality of understanding about natural phenomena at a microcosmic no less than at a microcosmos level, which is available to it. Such knowledge also enables a measure of control over natural phenomena, so that science, when manifested as technology, or sympathetic magic, provides the individual with the means of increasing his productive capacities and enriching his cultural life. When we touch upon the term 'philosophy', we encounter a plurality of frames of cognition. We deal, in the first instance, with the existential principles which sustain social behaviour and spiritual realisation. We also touch upon the normative principles which help the individual to attain social poise and moral self-realization. Last of all, we encounter the term 'culture', which needs to be defined in the most comprehensive manner possible. When we address ourselves to culture comprehensively, we are dealing with both spiritual and material acts of creation and consumption. Yet cultural production is as much a social as it is an individual activity. Further, not only are those who specialise in cultural production, but also those who consume the products of such specialised activity, themselves constantly engaged in acts of cultural creativity. In this context, it may be re-emphasized, that culture pertains as much to material and tangible objects,

like pieces of furniture and textiles, as it pertains to intangibles, like a poem or work of art.

It would be appropriate to strike a note of caution about the facile manner in which we have attempted to define concepts which are equally liable and complex in their configuration and structure. We have done so partly because we look upon definitions as the points of commencement of humanistic exploration rather than the end products of such exploration. The notion of definitions as heuristic devices is a valuable notion, since it demystifies definitions at the same time as it ensures the cognition of social reality and the development of reified theory.

Yet another issue worth considering is the question of 'fragmentation' of reality and its cognitive consequences. For a scholar located in our times, it is impossible to wholly avoid 'fragmentation' as an analytic method, irrespective of the discourse which informs his intellectual labour. To illustrate what I mean, let me dwell on the very title of our project, namely, *A History of Science, Philosophy and Culture in Indian Civilization*. As a product of modernity, the title assumes, or at least suggests, the existence of discernible boundaries between 'science', 'philosophy' and 'culture', not to mention 'Indian' and 'Civilization'. This is so even though it has been argued earlier that the fragmentation of knowledge results in partial, or even erroneous, knowledge. Nevertheless, due to a fall from temporal innocence, the modern sensibility cannot but treat these facets of possibly integral knowledge as discrete configurations of rational comprehension. That the reflective tradition of India was, and still remains, tied to a holistic approach is besides the point. All we can do is to *attempt* to transcend that fragmentation which modernity has irreversibly introduced in human cognition no less than in scientific and cultural production.

Perhaps the design of the volumes, which we seek to create as the constituents of 'A History of Science, Philosophy and Culture in Indian Civilization', are crucial to our enterprise. Beyond highlighting the need to transcend *all* existing notions of temporality and the fragmentation of knowledge, we need to devise a strategy of locating and of organising knowledge which facilitates such transcendence. As is well known, there are two alternative modes of planning a multi-volume series, with the truly comprehensive range which we are seeking to capture in our intellectual endeavour. It is possible, in the Cartesian spirit to pick upon identifiable and well defined themes—like the generation of concrete ideas; or the production of specific material objects—and pursue them across linear time. Many exercises tend to follow such a logic and method. Alternatively, it is possibly to break-up the diverse

themes with which we are concerned into well defined temporal phases. The second of the two modalities facilitates that integrality of the knowledge, scientific and humanistic, which we propose to locate in our discourse. It may also help us conceptualise ambiguous temporality as the most desirable notion of time.

It would be the reverse of true to suggest that our proposed mode of exploration takes carefully of that discourse of fragmentation which we are seeking to exercise from our project. At the same time, the placement of concepts and activity which modernity has mapped out as discrete domains, in a unified narrative, offers the possibility of recapturing some of the strengths of holistic knowledge. Our notion of temporality, with its highly self-conscious ambiguity, would work towards a similar objective. It is not given to mortal man to recover the lost wisdom of a bygone era. Nevertheless, we may strive to transcend some of the limitations which a flawed modernity has placed in the way of a rounded appreciation of the scientific, philosophical and cultural heritage of Indian civilization.

NOTES AND REFERENCES

1. Professor D.P. Chattopadhyaya, the distinguished philosopher and humanist, has circulated a number of seminal papers on this theme. They provide the conceptual basis of the whole exercise. My own 'Note' is a longish 'comment' provoked by what Professor Chattopadhyaya has stated.
2. F. Whyte, *The Pioneers of the French Revolution* (Boston, 1920).
3. Quoted in Edwin R.H. Sehgmán (ed.), *Encyclopaedia of the Social Sciences*, vol. v (New York, 1963), pp. 528-9.
4. Lord Acton, 'Letter to Contributors to the Cambridge Modern History', in W.H. McNeill (ed.) *Essays in the Liberal Interpretation of History* (Chicago, 1967), pp. 396-9.
5. Ibid., p. 397.
6. 'Introduction' by W.H. McNeill in *ibid.*, p. xiii.
7. Preface in Joseph Needham, *Science and Civilization in China*, vol. 1, *Introductory Orientations* (Cambridge, 1979), pp. 1-2.
8. Ibid.
9. I owe the notion of 'fuzzy' time to Professor Sudipto Kaviraj of the School of Oriental and African Studies, University of London.

ਮੰਗਲਾਨੀ ਕਾਨੂੰਨੀ ਸੰਸਥਾ

